Revised Upland Feasibility Study Terminal 4 Slip 1 Upland Facility Portland, Oregon

Prepared for:
Port of Portland

August 18, 2011
1065-01

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Revised Upland Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Prepared for:
Port of Portland

August 18, 2011
1065-01

REGISTERED PROFESSIONAL ENGINEER
18,147 PE
OREGON
OCT. 2, 1990
HERBERT F. CLOUGH
EXPIRES: DEC. 31, 2011

Herb Clough, P.E.
Principal Engineer, Ash Creek Associates

for

Michael J. Pickering, R.G.
Associate Hydrogeologist, Ash Creek Associates

3015 SW First Avenue
Portland, Oregon 97201-4707
(503) 924-4704 Portland
(360) 567-3977 Vancouver
(503) 943-6357 Fax
www.ashcreekassociates.com

Table of Contents

Tables

Figures

Abbreviations/Acronyms

%UCL	Percentile Upper Confidence Limit
AINW	Archaeological Investigations Northwest
AOCs	Areas of Concern
Ash Creek	Ash Creek Associates, Inc.
bgs	Below the Ground Surface
BMPs	Best Management Practices
BUD	Beneficial Land and Water Use Determination
City	City of Portland
City CPD	City of Portland Commission of Public Docks
COIs	Constituents of Interest
COPCs	Constituents of Potential Concern
CSM	Conceptual Site Model
DEQ	Oregon Department of Environmental Quality
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
Facility	Terminal 4 Slip 1 Upland Facility
FS	Feasibility Study
HHRA	Human Health Risk Assessment
IH	Heavy Industrial Use
LOF	Locality of the Facility
mg/kg	Milligram per Kilogram
MSL	Mean Sea Level
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
OAR	Oregon Administrative Rule
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
Port	Port of Portland
RBC	Risk-Based Concentration
RAO	Remedial Action Objective
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
SMP	Soil Management Plan
USGS	United States Geological Survey
VCP	Voluntary Cleanup Program

1.0 Introduction

The Port of Portland (Port) is under a Voluntary Cleanup Program (VCP) Agreement (dated December 4, 2003) with the Oregon Department of Environmental Quality (DEQ) for Remedial Investigation (RI), Source Control Measures, and Feasibility Study (FS) at the Terminal 4 Slip 1 Upland Facility (the Facility) located in Portland, Oregon. This FS report was prepared to meet the report requirement of the VCP Agreement and Scope of Work. A Facility location map is provided on Figure 1; a Facility plan is provided on Figure 2.

1.1 Purpose and Scope

The purpose of the FS was to evaluate remedial options and select a remedial alternative that addresses the unacceptable risk identified in the RI in accordance with the requirements of DEQ rules and guidance. Consistent with the RI, the scope of the FS was limited to the upland Facility. As described in the VCP Agreement, the upland Facility is that area above the ordinary line of low water of the Willamette River at Slip 1 and Wheeler Bay. The upland Facility boundaries are shown on Figure 3.

The FS was conducted in accordance with the outline submitted to the DEQ on November 29, 2007. A draft report was submitted to the DEQ in August 2008, and the DEQ provided comments to the Port in a letter (DEQ, 2008). Prior to completion of the final FS, the Port elected to conduct additional soil sampling to supplement the data set in support of the FS. This report was prepared pursuant to the VCP Agreement and Oregon Administrative Rule (OAR) 340-122-0085 and OAR 340-122-0090; and in accordance with guidance from the U.S. Environmental Protection Agency (EPA; 1988) and the DEQ *Guidance for Conducting Feasibility Studies* (DEQ, 1998a).

1.2 Report Organization

The following is a brief overview of the organization of the report.

Site Background. Section 2 describes the Facility setting (location, geology and hydrogeology, surface hydrology, and climate), the Facility history, and a summary of previous environmental investigations. This section also discusses the areas of concern (AOCs) on the Facility.

Beneficial Land and Water Use Determination. Section 3 describes the Beneficial Land and Water Use Determination (BUD) for the Facility, including the site setting, the Facility land use (historical, current, and future), beneficial water uses (groundwater and surface water), and potential future water uses.

Conceptual Site Model. The information from Sections 2 and 3 are evaluated in Section 4, which summarizes the conceptual site model (CSM) for the Facility. This section includes a description of the nature and extent of the constituents of interest (COI), the Locality of the Facility (LOF), and exposure pathways for human health and ecological receptors.

Risk Assessment Summary. Section 5 includes a summary of the human health and ecological risk assessments that have been completed for the Facility.

Remedial Action Objectives and Remedial Action Area. Section 6 defines and discusses the appropriate remedial action objectives (RAOs) for the Facility and the criteria by which potential remedial action alternatives will be evaluated. The extent of the area that contains media exceeding concentrations identified in the RAOs is described in Section 7.

Technology Evaluation and Remedial Action Alternatives. A list of general response actions are developed and presented in Section 8 to address the conditions encountered in the remedial action area described in Section 7. These general response actions form the basis for generating and screening technologies. Potential remedial technologies were developed for each general response action identified. Technologies were then evaluated with respect to specific Facility conditions, waste characteristics, and the ability to achieve the RAOs. The technologies remaining after the screening process were then combined to create potential alternatives for further detailed analysis.

Detailed Analysis of Remedial Alternatives. The potentially feasible remedial action alternatives are more fully developed in Section 9. The protective alternatives are evaluated on the basis of the balancing factors: effectiveness; long-term reliability; implementability; implementation risk; and reasonableness of cost. The evaluation includes sufficient detail to identify comparative or relative differences among alternatives.

Comparative Evaluation of Remedial Action Alternatives and Recommendation. After completion of the detailed screening, the feasible remedial alternatives are then ranked. The alternatives are ranked within each of the balancing factors in Section 10. Within each balancing factor, the alternatives are compared to generate an overall ranking. Based on the results of the comparison rankings, a remedial action alternative is recommended. The recommended remedial action alternative is discussed in Section 11.

2.0 Background

2.1 Physical Setting

2.1.1 Facility Description

Terminal 4 is located in the NW 1/4 and NE 1/4 of Section 2, Township 1 North, Range 1 West of the Willamette Meridian, Portland, Multnomah County, Oregon. The Facility location is included on the Linnton

Oregon U.S. Geological Survey (USGS) 7.5-Minute Quadrangle map (USGS, 1984). The topography of the Facility is relatively flat, with an elevation of approximately 30 feet above mean sea level (MSL). Developed areas of the Facility are generally covered with buildings, asphalt or concrete pavement, or rail lines. In unpaved areas, the ground surface of the Facility consists mainly of gravel and sparsely vegetated soil areas. No surface-water bodies are located on the Facility, but it is located adjacent to the Willamette River.

Terminal 4 comprises approximately 283 acres on the east bank of the lower Willamette River and is downstream from the St. Johns Bridge in North Portland, between River Miles 4.1 and 4.6. The portion of Terminal 4 identified as the Slip 1 Upland Facility (the Facility) is approximately 98 acres in area. The vicinity of the site is shown on Figure 1. The Facility is located at the northern end of the terminal and is bounded to the north by the Schnitzer Steel Products facility property boundary; to the east by the Terminal 4 property boundary; to the south by the Willamette River (Wheeler Bay and Slip 3) and the boundary of the Terminal 4 Slip 3 Upland Facility; and to the west by the ordinary line of low water of the Willamette River at Slip 1 and Wheeler Bay.

The VCP Agreement divides the Facility into two Operable Units (OUs): OU1 and OU2 (as shown on Figure 2). OU1 consists of an approximately 53-acre northern portion of the Facility, which encompasses the former Cargill leasehold. OU2 consists of the remainder of the Facility and is approximately 45 acres in area.

The Port acquired the property constituting the Facility in 1971 from the City of Portland Commission of Public Docks (City CPD). The City CPD purchased the property in 1917 as part of the original 117.55-acre site for the St. Johns Terminal. This included approximately 36 acres of submerged land around the former Gatton Slough, which entered the river near the head of Slip 1 (Figure 2). Development of the terminal resulted in the filling of Gatton Slough and adjacent areas within the river, and excavation of Slip 1. In 1972, the Port purchased a strip of land along the northern property line from Broadway Holding Company in connection with the relocation of the grain berth to the face of current Berth 401.

The Port leases portions of the Facility to various tenants. Figure 3 shows the location of current and recent tenant-occupied areas at the Facility.

2.1.2 Geology and Hydrogeology

Geology. The Facility is underlain by three primary geologic units: the Fill Unit (sand fill); the Alluvial Unit; and the Troutdale Formation. Locally, the Fill Unit consists of sand fill and varies in thickness from about 10 feet on the east side of the Facility to greater than 35 feet near the river. The Alluvial Unit consists of interbedded silt, silty sand, and sandy silt. The base of the Alluvial Unit is at a depth of about 85 to 150 feet below the ground surface (bgs). Sandy gravel encountered beneath the Alluvial Unit was interpreted to represent the Troutdale Formation. The local thickness of the Troutdale Formation is estimated to be about 100 feet (Ash Creek Associates [Ash Creek]/Newfields, 2007a).

Hydrogeology. Groundwater has been encountered within the Fill Unit and upper portion of the Alluvial Unit at depths of 8.3 to 30 feet bgs (1.1 to 17.4 feet MSL). Seasonal water level fluctuations in inland monitoring wells were generally less than 2 feet. Monitoring wells along Slip 1 and the Willamette River have had an observed seasonal water level fluctuation of approximately 4 feet.

Groundwater flow within the Fill and Alluvial Units at the Facility is generally toward the Willamette River, Slip 1, or Slip 3. Because the Slips extend well into the Facility, the shallow groundwater gradient within the Fill and upper Alluvial Units is relatively flat beneath the western portions of OU1 and OU2. The hydraulic gradient in the central portions of each OU is approximately 0.01 and the gradient again decreases to approximately 0.001 in the eastern portion of the Facility (Ash Creek/Newfields, 2007a).

2.1.3 Surface Hydrology

The Facility is located adjacent to the Willamette River. Surface hydrology at the Facility consists primarily of surface runoff as sheet flow during rainfall events. Much of the sheet flow is captured through a permitted, piped storm water conveyance system. There are also localized areas of potential direct discharge to the Willamette River on the northern bank of Slip 1 and infiltration into the surface soils in the vicinity of outfall W3 (Wheeler Bay).

Storm water and the storm water conveyance systems at the Facility are actively managed by the Port under the Port's National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) Permit Number 101314, and by Port tenant Kinder Morgan, under an industrial storm water permit. These permits authorize the release of storm water to the river subject to specified terms and conditions and also require the implementation of best management practices (BMPs; see Section 4.5). The Port and its tenants implement the terms and conditions of their permits and report annually to DEQ. Based on a review of records, the Port and Kinder Morgan are currently in compliance with their permits.

The river stage is typically between 3.7 and 11.7 feet MSL, based on information from the Morrison Bridge gauge. The diurnal tide range is 2.2 feet at low river stage and becomes progressively less with higher river stages (NOAA, 2003). According to the Federal Emergency Management Agency Flood Insurance Rate Map, City of Portland, Oregon, Map Number 410183-0015C, dated October 19, 1982, the majority of the Facility is located within Zone C, with minor portions adjacent to the river and Slips located within Zone B. Zones B and C are described as areas between limits of the 100-year flood and 500-year flood, or certain areas subject to 100-year flooding with average depths less than 1 foot, or where the contributing drainage area is less than 1 square mile, or areas protected by levees from the base flood.

2.2 Environmental Investigations

Remedial Investigation. For the period from 1989 to 2005, a variety of site investigations were completed, culminating in the RI in 2004 and 2005. A summary of these investigations and the results were incorporated into the RI Report (Ash Creek/Newfields, 2007a). Results of the RI and Risk Assessment are discussed in Sections 4 and 5.

Supplemental Surface Soil Sampling. Additional surface soil sampling was completed after the RI to supplement the data set in support of the FS. Results of the surface soil sampling are presented in letter reports (Ash Creek; 2009a, 2010, and 2011) and were used together with the RI data to define the remedial action areas in Section 7.

Storm Water Evaluation. In 2007, the Port conducted four rounds of storm water sampling from multiple drainage basins at Terminal 4. The results of the sampling are reported in the Terminal 4 storm water data summary report (Ash Creek, 2009b) and are summarized in Section 4.2. In June 2010, the Port completed cleanouts of storm water conveyance lines in multiple drainage basins at Terminal 4, including post-cleanout storm water sampling. The cleanouts were conducted in accordance with the DEQ-approved *Storm Water Source Control Evaluation* report (Ash Creek, 2009c) and subsequent correspondence. Results from the storm water line cleanouts and storm water sampling program will be presented in a report that is currently under preparation.

2.3 Areas of Concern

The evaluation of the historical data and investigations prior to the RI identified 83 potential AOCs (Ash Creek/Newfields, 2007a). Of these, 35 potential AOCs were determined to have sufficient information to not warrant further investigation during the RI. The remaining 48 potential AOCs were further evaluated during the RI and Risk Assessment. The results of the Risk Assessment and supplemental sampling indicated four areas that contained constituents of potential concern (COPCs) at concentrations that exceeded risk screening criteria and had some potential for unacceptable risk if not managed or otherwise addressed. These areas are as follows:

- The Abandoned Cesspool east of the Cereal Foods buildings (AOC 15);
- Areas in the northwest corner of OU1 associated with the Railroad Track Staining Area (AOC 9) and the Auto Fluff Area (AOC 29);
- The Erodible Bank Area (AOC 83); and
- Soil Stockpile Area.

The above areas are shown on Figure 4.

2.4 Cultural Resources

Archaeological Investigations Northwest (AINW) conducted a cultural resources survey for Terminal 4 (AINW, 2003). A summary of survey findings is included in Appendix E of the RI Work Plan (Hart Crowser, 2004). AINW identified the former banks of the Willamette River and Gatton Slough as high-probability areas for archaeological resources associated with Native American use and occupation of the Terminal 4 area.

3.0 Beneficial Land and Water Use Determination

This section summarizes the BUD for the Facility completed as part of the RI. The BUD was completed in accordance with DEQ guidance documents (DEQ, 1998b and 1998c). The purpose of the BUD is to document historical, current, and reasonably likely future land and water uses at the Facility and adjacent properties. The results of the BUD were used to support development of the CSM for the Facility.

3.1 Facility Land Use

Terminal 4 Slip 1 is located at the northern end of Terminal 4. The Facility is entirely used for industrial and marine land uses and is surrounded by facilities with similar uses. Historical, current, and future land uses are summarized as follows:

- The Facility history is summarized in Section 2.1.1. The Facility has been designated for use or used as a marine terminal since 1917. The Port acquired the property constituting the Facility in 1971 via merger with the City CPD. The City CPD purchased the property in 1917 as part of the original 117.55-acre site for the St. Johns Terminal.
- The Port leases portions of the Facility to various industrial tenants. Figure 3 shows the location of current and recent tenant-occupied areas at the Facility. Current zoning information indicates the entire site is designated for Heavy Industrial (IH) use by the City of Portland's (City) Bureau of Planning (Title 33, Planning and Zoning, Chapter 33.140). IH zoning provides areas where many industries may locate, including those not desirable in other zones due to their objectionable impacts or appearance (City, 2004a).
- The entire Facility and surrounding properties are designated by the Portland Comprehensive Plan Map as industrial sanctuary (City, 2004b). The Portland Comprehensive Plan Map is not the same as the Zoning Map. The Comprehensive Plan Map is an official description of where and to what level future zoning should be permitted, and presents a pattern for future development that will accomplish the purposes of applicable land use policies. Legally, zoning must comply with the limits set by a Comprehensive Plan. Thus, the land use designations of a Comprehensive Plan are superior to those used in the Zoning Map (i.e., the Zoning Map cannot allow land uses which are more intensive than those allowed by the Comprehensive Plan Map). As stated previously, the Comprehensive Plan includes the Facility as part of an industrial sanctuary, which is intended for areas where City policy is to reserve land for existing and future industrial development. A full range of industrial uses are permitted and encouraged, while non-industrial uses are limited to prevent land use conflicts and preserve land for industry.

Therefore, the Facility is currently, and is reasonably expected to remain for the foreseeable future, zoned for IH use.

3.2 Beneficial Water Uses

3.2.1 Groundwater

Beneficial water uses were researched for the RI (Ash Creek/Newfields, 2007a) and are summarized as follows. A municipal water source supplies the Facility with potable water for drinking and other purposes. There are no active groundwater supply wells on Terminal 4 Property. Historically, an industrial well was located at the former Cargill grain leasehold. This well was abandoned in 1992.

Water well records indicate 12 water wells are/were located in the vicinity of the Facility. One industrial well is located at Northwest Pipe and one well is located at Schnitzer Steel. Both are used only in the summer for cooling purposes. Three wells were identified at Northwest Container, with one well used part of the year for washing storage containers; the other two wells are inactive. Five wells were installed northeast of the Facility during the 1940s for industrial use; their status is unknown. The remaining two wells were located over 1 mile from the Facility and were used for irrigation purposes only. These wells are located cross-gradient or upgradient of the Facility and it has been reported that these wells were capped in the early 2000s.

3.2.2 Surface Water

The stretch of the Willamette River adjacent to the Facility, to which local groundwater discharges, is used mainly for commercial/industrial and recreational activities. The Facility is within the Portland Harbor Superfund Site Study Area (from River Mile 1.9 to River Mile 11.8).

The Willamette River also serves as an active channel for large commercial ships to River Mile 11.7. The U.S. Army Corps of Engineers has dredged portions of the Willamette River in the past in order to facilitate commercial use of the channel. Anadromous and resident fish species, some of which are threatened or endangered, use parts of the Willamette River during various stages in their life cycles. A number of local Native American tribes have fishing rights at usual and customary locations on the lower Willamette River. The lower Willamette River is also used for fishing for sport and consumption, subject to Oregon Department of Fish and Wildlife (ODFW) regulations.

No active surface water points of diversion were identified at locations on or immediately adjacent to the Facility.

3.2.3 Future Water Use

Anticipated future uses of groundwater and surface water within and in the area of the LOF are the same as current uses. Properties and potential users within the LOF are connected to the public water supply system. No current domestic use of groundwater was identified although area groundwater is occasionally used for industrial cooling purposes. Reasonably likely future groundwater use may include industrial uses. The public water supply system is expected to meet future area drinking and other domestic water needs.

3.2.4 Beneficial Water Use Determination

The results of the water use survey indicate area users rely on the municipal water supply to meet drinking water and other domestic needs. Industrial wells located at the Northwest Pipe and Schnitzer Steel facilities are used only in the summer for cooling purposes. The entire area is within the limits of the City and is currently served by the City's water supply system. A beneficial water use checklist, consistent with DEQ guidance, follows.

Beneficial Water Use	Current Use?	Future Use?	Justification
Drinking Water	N	N	The site is served by municipal water.
Irrigation	N	N	The site is served by municipal water.
Livestock	N	N	No livestock are raised in the LOF.
Industrial	N	N	The site is served by municipal water.
Engineering	N	N	The site is served by municipal water.
Aquatic Habitat	Y	Y	Groundwater discharges to the Willamette River that supports aquatic species.
Recreation	Y	Y	Groundwater discharges to the Willamette River that is used for fishing and other recreation.
Aesthetic Use	Y	Y	Groundwater discharges to the Willamette River that has aesthetic beneficial uses for the community.

Notes: Y = Yes
N = No

4.0 Conceptual Site Model

Information on the Facility historical setting and beneficial water and land use (as detailed in Sections 2 and 3) and the results of the RI (Ash Creek/Newfields, 2007a) were assessed to develop a CSM of the site. Figure 5 presents the human health and ecological CSMs.

4.1 Physical Setting

Details of the physical setting for the Facility were provided in Sections 2 and 3. In summary, the 98-acre upland Facility is located adjacent to the Willamette River. The topography is relatively flat, with steep riverbanks in some areas. The ground surface of the Facility consists of a combination of asphalt or concrete paved areas, structures, railroad track alignments and rail spurs, and sparsely vegetated open space. The Facility is leased to multiple tenants and actively used for various industrial purposes.

Most of the riverbanks are heavily vegetated and/or covered with riprap. Surface hydrology at the Facility consists primarily of surface runoff as sheet flow during rainfall events. The sheet flow is captured through a permitted, piped storm water conveyance system with storm drains, catch basins, and outfalls to the Willamette River.

The Port acquired the property in 1971 from the City CPD. The City CPD purchased the property in 1917. Development of the terminal resulted in the filling of Gatton Slough and adjacent areas within the river, and excavation of Slip 1. Soil underlying the Facility consists of sand fill overlying silty native alluvium. The upper portions of the silty alluvium consist of silty sand; the amount of silt appears to increase with depth and likely presents a confining layer to significant downward flow. Depth to groundwater ranges from 8.3 to 30 feet bgs (1.1 to 17.4 feet MSL). Groundwater flows to the Willamette River or Slips 1 or 3 at a gradient ranging between 0.01 and 0.001. Shallow (first encountered) groundwater is contained primarily in the sand fill or upper silty sand alluvium. Groundwater velocity in the sand fill and upper silty sand alluvium is conservatively estimated to range from 4 feet per year in the eastern parts of the Facility to 400 feet per year as the groundwater nears the Slips. Groundwater gradients are flat on the western portions of OU1 and OU2 and velocity is likely low from these areas towards the river.

4.2 Nature and Extent of Constituents of Potential Concern

As described in Section 2, potential AOCs were identified and investigated for the RI. A subsequent Risk Assessment evaluated the soil and groundwater quality at the Facility to determine whether potentially unacceptable risks may be present (due to the presence of constituents in site soil or groundwater) and whether risk management tools (e.g., remedial action, media management plans, etc.) are needed to protect human or ecological health. This section summarizes the soil and groundwater conditions in the context of the overall Facility (as opposed to each AOC) to assist in the understanding of Facility-wide conditions supporting the Risk Assessment (which is discussed in Section 5).

Soil. With the exception of a few localized areas and along the riverbanks, COIs were detected intermittently in soil at generally low concentrations. The localized areas identified in the RI (Ash Creek/Newfields, 2007a) as AOCs are shown on Figure 4. Based on the RI and subsequent sampling (Ash Creek, 2009a, 2010, and 2011), areas with COIs above acceptable risk levels consist of the following:

- A limited area of surface soil (upper 6 to 12 inches) in the western portion of OU1 contains multiple polycyclic aromatic hydrocarbons (PAHs) exceeding risk-based concentrations (RBCs). The PAHs are likely due to asphalt materials entrained in the surface soil.
- An area of surface soil (upper 2 feet) near the northwest Facility boundary contains PAHs exceeding RBCs.
- Deeper soil (greater than 13 feet below grade) in the area of four former cesspools in the northern central portion of OU1 contains total petroleum hydrocarbons and PAHs.
- An area of riverbank soil in Wheeler Bay contains PAHs, pesticides, and metals above RBCs.
- Soil stockpiles northeast of Slip 1 contain benzo(a)pyrene above the RBC. The PAHs are likely due to asphaltic materials entrained in soil during its excavation.

Section 5 presents a summary of the potential risk posed due to the presence of these constituents in Facility soil.

Groundwater. No groundwater plumes originating at the Facility were identified. Intermittent low detections of some COIs (PAHs, pesticides, metals) were observed during the quarterly monitoring program of the monitoring wells. Often, a COI was detected during only one of four quarters of sampling, suggesting that variability in sample turbidity was the reason for the detection and supporting that significant dissolved-phase COIs are not present at the Facility. The Risk Assessment (summarized in Section 5) evaluated the potential risk posed due to the low and intermittent presence of these constituents in Facility groundwater.

Storm Water. Storm water sampling completed at the Facility included collection of storm water and storm water solids samples from four of the seven drainage basins (see Figure 6) at the Facility and analyzing the samples for a range of COIs (Ash Creek, 2009b). Metals, phthalates, pesticides, PCBs, and PAHs were detected in samples above Joint Source Control Strategy (JSCS) screening levels in at least one sampling event from each basin. However, concentrations of these chemicals were within the ranges detected at other heavy industrial sites throughout the Portland Harbor except for metals and PAHs in Basin L and metals and PCBs (one event) in Basin M. The higher relative concentrations of these COIs in Basins L and M did not correlate with current activities or upland surface soil sample analysis results from the RI. It appears that the presence of these chemicals may be related to legacy concentrations of COIs present in solids within the storm water conveyance system. Source control measures implemented to address the legacy sediments are discussed in Section 4.5.

4.3 Locality of the Facility

The LOF is any point where a human or an ecological receptor contacts or is reasonably likely to come into contact with COPCs from the Facility. The LOF takes into account the likelihood of the chemical constituents migrating over time.

For this project, the entire Facility is considered to be within the LOF for soil contact (due to detections of COIs in Facility soil). As described in Section 2, groundwater flow at the Facility is toward the Slips or the Willamette River. Therefore, the groundwater LOF comprises the upland Facility (including the adjacent riverbank) and the river. Properties to the north, west, and south are not included in the LOF because groundwater does not flow toward these properties.

4.4 Wheeler Bay Source Control

Because the Wheeler Bay riverbank area described above in Section 4.2 was an area of potentially erodible soil, a source control alternatives analysis was completed (Ash Creek/Newfields, 2007b). Based on the analysis, the DEQ selected bank stabilization as the source control measure (SCM) for Wheeler Bay.

The work was conducted as part of the Phase I Removal Action at Terminal 4 that included in-water sediment removal and capping. Through that design (Phase I), the EPA determined a cap over the stabilized shoreline was also prudent (Anchor, 2008). The Wheeler Bay shoreline stabilization project was completed between August and October 2008 (Ash Creek, 2009d). Construction was overseen by the EPA and activities were documented with daily reports, photographs, and detailed submittals. In summary, the Wheeler Bay shoreline stabilization activities included the following:

- Utility Relocation – Utilities located along the top of bank (telephone, electrical) were moved out of the area of site grading.
- Site Grading – Site grading was conducted to flatten the overall slope of most of the Wheeler Bay shoreline to 3 Horizontal to 1 Vertical. Concrete debris was removed from the site for recycling. Vegetation, miscellaneous debris, and excess soil were disposed of in an off-site landfill.
- Armor Stone/Habitat Cover/Large Woody Debris – From elevation 10 feet to 15 feet (NGVD), armor stone (rip rap) was placed to resist erosive forces of river currents, boat wakes, and waves. The armor stone was covered with sand/gravel, habitat logs, and Large Woody Debris to enhance the habitat for fish.
- Topsoil and Planting – Above elevation 15 feet, the slope was covered with a topsoil cap and erosion control fabric. The lower portion (between elevation 15 and 20 feet) was planted with cottonwood and willow trees. The portion above elevation 20 feet was planted with a native grass seed mix.

As a result of the Wheeler Bay shoreline stabilization project, the Wheeler Bay AOC is now capped. In June 2010, erosion along portions of the shoreline stabilized area was observed. The Port updated the Phase I design for this area of Wheeler Bay to repair the slope and prevent this level of erosion from happening in the future (Anchor, 2010). The repair work was completed in October 2010.

4.5 Storm Water Source Control

The Port is implementing a storm water source control action at the Facility consisting of a multi-phase approach of completed and planned activities, summarized as follows (Ash Creek, 2009c; Port, 2010; DEQ, 2010).

- Best Management Practices. The Port has implemented numerous BMPs at Terminal 4 as part of its tenant and licensee contracts, Environmental Management System Program, and continual improvement policy. The following is a list of BMPs that are specifically related to activities conducted at Terminal 4 under the Storm Water Management Plan for the MS4 permit.
    - Storage, material, and maintenance areas are covered to reduce storm water contact.
    - Procedures are in place to prevent and control spills associated with waste chemical handling, storage, and disposal.
    - Regular inspection, cleaning, and maintenance are conducted of all materials handling and storage areas and storm water control measures, structures, catch basins, and treatment facilities to prevent blocking, accumulations, and discharge of pollutants.
    - Catch basins are cleaned annually with appropriate treatment/disposal of residuals.
    - Catch basin inserts have been deployed and are maintained annually in catch basins in drainage Basins N, O, and Q.
    - Sweeping of impervious areas exposed to storm water is conducted annually.
    - During the Berth 408 Rail Yard Modernization Project, a passive storm water collection system was installed consisting of rock filter areas and perforated pipe. Storm water is filtered by the rock areas prior to discharging to the perforated pipe which connects to the storm water system.
    - A Stormfilter® treatment system (cartridge filtration of storm flows targeting oil and grease, soluble metals, organics, and nutrients) is present in the conveyance system for Basin M.
    - Landscape maintenance is conducted in accordance with published guidance for limiting impacts to storm water.
    - A comprehensive Spill Response Program (including a reporting component that provides for immediate action to ensure appropriate and timely spill cleanup and reporting) has been implemented.

- The Port is a member in the City's Regional Spill Committee and the Maritime Fire and Safety Association, which are organizations committed to spill prevention and response, and the ongoing protection of maritime environments.
- The Port administers a training program for affected personnel who play a role in the protection of storm water.

- Storm Water Conveyance Line Cleanout. The Port has conducted a cleanout of accumulated solids from conveyance lines in Basins K, L, M, N, and R (see Figure 6). Basin R lines were cleaned out in October 2007. Basins K, L, M, and N were cleaned out in June 2010 in accordance with the plan approved by DEQ in March 2010 (DEQ, 2010).
- Storm Water Confirmation Sampling. Confirmation storm water sampling was conducted for Basins L, M, and Q following the line cleanouts. Although conveyance line cleanout was not proposed for Basin Q, confirmation storm water sampling were conducted because prior sampling preceded demolition of large steel grain tanks previously located in that basin. The scope of the sampling is outlined in the storm water evaluation (Ash Creek, 2009b). A report of results is currently under preparation.

5.0 Summary of Risk Assessment

A screening level Human Health Risk Assessment/Ecological Risk Assessment (HHRA/ERA) was conducted as part of the RI (Ash Creek/Newfields, 2007a). The results of the HHRA/ERA are summarized in this section.

5.1 Conceptual Site Models and Exposure Pathways

The CSM developed in the Risk Assessment is shown on Figure 5. The potential human receptors (assumed exposed persons) are occupational workers, excavation workers, construction workers, and recreational fishers. The assumption of direct exposure to affected soil or groundwater applies only to the occupational, excavation, and construction workers; these pathways involve routes of exposure including inhalation of fugitive dust or vapor emissions, incidental ingestion, and dermal contact. The recreational fisher involves a potential route of exposure by consumption of fish.

The potentially complete ecological direct contact exposure pathways outlined in the Risk Assessment (Figure 5) included: (1) direct contact with contaminated surface or subsurface soil through contact with external surfaces or ingestion (terrestrial receptors); or (2) direct contact or ingestion of contaminants that have been transported to surface water or sediments in the Willamette River (aquatic receptors).

The potentially complete ecological indirect contact exposure pathways outlined in the CSM include: (1) ingestion of terrestrial food sources that have become contaminated through direct or indirect pathways (i.e., food web exposure); or (2) ingestion of aquatic food sources that have become contaminated through direct or indirect pathways (i.e., food web exposure).

5.2 Summary of Human Health Risk Assessment

An HHRA was prepared (Ash Creek/NewFields, 2007a) and under the current, limited use scenario, risks are acceptable. Additional risk screening was conducted on results from supplemental soil sampling (Ash Creek, 2011). In the event the Facility is redeveloped and use intensifies, the following unacceptable risks were identified for soil:

- Potential risks from benzo(a)pyrene and cumulative PAH exposure are greater than 10^{-6}, but less than 10^{-5}, for the future occupational worker in OU1;
- Potential risks from benzo(a)pyrene and dibenz(a,h)anthracene are greater than 10^{-6}, but less than 10^{-5}, for the future occupational worker in OU2; and
- Additive risk from PAH exposure is only slightly greater than 10^{-5} for the future occupational worker in OU2.

The areas that contain soil COPCs resulting in potential for unacceptable risk (if not managed or otherwise addressed) include the following:

- <u>OU1</u>: S-12/S-13 Subarea with concentrations of a few PAHs in surface soil;
- <u>OU1</u>: Former cesspool area with concentrations of a few PAHs in deep soil;
- <u>OU1</u>: Soil stockpiles with a benzo(a)pyrene in soil;
- <u>OU2</u>: Location S-14 with concentrations of several PAHs in surface soil (visibly stained with creosote) located adjacent to a utility pole; the pole was removed and the area was graded and filled during the recent Berth 408 Rail Yard Modernization Project; and
- <u>OU2</u>: Wheeler Bay riverbank with erodible bank areas that have PAHs. This area was capped during the Wheeler Bay source control action (see Section 4.4).

The Risk Assessment concluded that groundwater contaminants are unlikely to be transported to surface water at levels that will result in unacceptable risk from fish ingestion.

5.3 Summary of Ecological Risk Assessment

Level I Scoping and Level II Screening ERAs were prepared (Ash Creek/NewFields, 2007a) and risks were acceptable for soil and groundwater.

5.4 Hot Spot Evaluation

Unacceptable risk was identified for human health resulting from PAHs present in soil. Therefore, the potential for human health Hot Spots in soil was evaluated by comparing the soil concentrations of benzo(a)pyrene and dibenz(a,h)anthracene to the highly concentrated Hot Spot level of 27 milligrams per kilogram (mg/kg; 100 times the occupational risk-based concentration). The maximum concentration of each of these chemicals is less than the Hot Spot level; therefore, there are no Hot Spots in soil at the Facility.

6.0 RAOs and Evaluation Criteria

6.1 Remedial Action Overview

The RI and Risk Assessment (Ash Creek/Newfields, 2007a) concluded that the presence of PAHs in the surface or subsurface soil in OU1 and OU2 will not present an unacceptable risk to potential current human receptors at the Facility based on the current limited use of these areas. Because there is the potential for unacceptable future risk to occupational workers from surface soil if the Facility is redeveloped for typical industrial use, this FS presents an evaluation of remedial action alternatives to address the potential unacceptable risk.

The COPCs driving the potentially unacceptable risk exposures to future occupational workers are PAHs. Benzo(a)pyrene is the main risk driver, with contributions to cumulative exposure from benzo[a]anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. It should be noted that these co-located PAHs were sufficiently low in concentration to have been eliminated as individual COPCs by the standard screening process. The Risk Assessment concluded that these PAHs would not lead to unacceptable human or ecological health risk if the potential future exposure was managed appropriately. The identified areas that require management associated with elevated concentrations of these COPCs include unpaved areas of shallow soil in the northwest corner of OU1 in the vicinity of AOCs 9 and 29, deeper soil near the former cesspools (AOC 15), soil stockpiles northeast of Slip 1, and the capped area on the Wheeler Bay bank (AOC 83). The S-14 sample area was associated with a *de minimis* quantity of soil at the base of a utility pole. The pole has been removed and the area was graded and filled during subsequent development. Therefore, the S-14 sample area is not included in the FS evaluation.

6.2 Remedial Action Objectives

DEQ provides applicable, current guidance regarding risk-based management of sites with contamination from petroleum constituents. This guidance, called *Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites* (DEQ, 2003; with 2009 updates), includes RBCs for the hazardous substances of interest, including RBCs relevant for occupational exposure to carcinogenic PAHs in soil. The RAO for the site will be to address the potential risk posed by benzo(a)pyrene and other PAHs by mitigating exposure in the identified remedial action areas to achieve site-wide concentrations below the following RBCs:

- Benzo(a)pyrene = 0.27 mg/kg
- Dibenz(a,h)anthracene = 0.27 mg/kg
- Benzo[a]anthracene = 2.7 mg/kg
- Benzo[b]fluoranthene = 2.7 mg/kg
- Indeno[1,2,3-cd]pyrene = 2.7 mg/kg

6.3 Evaluation Criteria

The evaluation of potentially feasible alternatives was based on the following criteria (OAR 340-122-085(4)).

6.3.1 Protectiveness

Protectiveness is a threshold requirement; only alternatives that meet the protectiveness requirements were evaluated (OAR 340-122-040). The protectiveness standards are:

- Ability of remedial action to protect present and future public health, safety, and welfare;
- Ability of remedial action to achieve acceptable risk levels specified in OAR 340-122-115;
- Ability of remedial action to prevent or minimize future releases and migration of hazardous substances in the environment; and
- Requirements for long-term monitoring, operation, maintenance, and review.

6.3.2 Balancing Factors

Balancing Factors include the following (OAR 340-122-090(3)):

- Effectiveness: Ability and timeframe of remedial action to achieve protection through eliminating or managing risk;
- Long-Term Reliability: Reliability of remedial action to eliminate or manage risk and associated uncertainties;
- Implementability: Ease or difficulty of implementing a remedial action considering technical, mechanical, and regulatory requirements;
- Implementation Risk: Potential impacts to workers, the community, and the environment during implementation; and
- Reasonableness of Costs: Considers capital costs, operations and maintenance, and periodic review, and includes a net present-value evaluation of the remedial action.

6.3.3 Treatment or Removal of Hot Spots

Hot Spots are evaluated based on the feasibility of treatment/removal of the Hot Spot using the above balancing factors with a higher threshold for cost reasonableness (OAR 340-122-085(5,6,7), -090(4)). The higher threshold is applied only as long as the Hot Spot exists. There were no Hot Spots identified applicable to this FS.

7.0 Remedial Action Area and Extent

Soil impacted by benzo(a)pyrene and dibenz(a,h)anthracene at concentrations that exceed the RAOs are found in five areas. Figure 7 shows the locations of these areas. These locations were generally determined by sampling completed for the RI (Ash Creek/NewFields, 2007a), but the extent of the areas in the northwest portion of the Facility and soil stockpiles were refined by supplemental surface soil sampling (Ash Creek, 2009a, 2010, and 2011) and construction work completed by the Port. Figure 8 is a compilation of surface soil PAH data in the northwest portion of the Facility that was used to refine the shallow soil remedial action area. Figure 9 shows the results of sampling conducted at the stockpiles. For the stockpiles, benzo(a)pyrene was detected above the RAO in only four of 25 samples, but because of the heterogeneous nature of the soil in the stockpiles, for the purpose of the FS, the entire stockpile volumes were included within the remedial action area.

The spatial characteristics of the remedial action areas are summarized as follows:

- Unpaved Western Surface Soil (two areas)
    - Depth below ground surface: 0 feet
    - Dimensions: 600 by 50 feet and 60 by 150 feet
    - Area: 39,000 square feet
    - Thickness: 2 feet
    - Volume: 2,900 cubic yards
    - Mass: 4,800 tons
- Cesspool Area
    - Depth below ground surface: Approximately 13 to 17 feet bgs (encountered beneath acceptably clean overburden)
    - Dimensions: 60 feet by 100 feet
    - Area: 6,000 square feet
    - Volume: 900 cubic yards
    - Mass: 1,500 tons

- Soil Stockpiles
    - Depth below ground surface: 0 feet
    - Area: 60,000 square feet
    - Thickness: 5 feet (average)
    - Volume: 10,700 cubic yards
    - Mass: 17,700 tons
- Wheeler Bay
    - Depth below ground surface: 0 feet (originally); now capped with 1 to 4 feet of clean soil
    - Dimensions: 60 feet by 820 feet
    - Area: 49,000 square feet

The extents of remedial action areas were generally defined by including any sample with concentrations exceeding RBCs within the remedial action areas. However, for situations where a sample exceeded the RBC by less than 1.5 times (and thus the risk ratio to the nearest single significant digit is one) and that sample is surrounded by samples below the RBC, the area represented by that sample was not included within the remedial action area. This situation applies to sample S-11 because the risk ratio is 1.1 and the six nearest samples surrounding S-11 have risk ratios ranging from 0.03 to 0.6. Thus, sample S-11 was not included within the remedial action areas. This approach is verified to be acceptable based on the residual risk calculations discussed in Section 11.2.

As discussed in Section 4.4, the Wheeler Bay riverbank was capped as part of a source control action. A *Source Control Alternatives Evaluation* (Ash Creek Associates/NewFields, 2007b) was completed for the Wheeler Bay bank. That evaluation was completed consistent with the requirements of an FS and justifies selection of the capping remedy for the bank. Each alternative evaluated in Section 9 includes capping of the Wheeler Bay bank.

8.0 Remedial Action Alternatives and Preliminary Screening

Initially, remedial actions associated with a list of general response actions were screened for applicability based on site and soil conditions and contaminant type. General response actions are broad categories of remedial measures that address the RAOs. A response action may be a stand-alone remedial action alternative or a component of a comprehensive alternative. The list of general response actions includes:

- No Action;
- Institutional/Engineering Controls;

- Removal;
- Containment;
- *In Situ* Biological Treatment;
- *In Situ* Physical/Chemical/Thermal Treatment;
- *Ex Situ* Biological Treatment; and
- *Ex Situ* Physical/Chemical/Thermal Treatment.

Table 1 lists the general response actions together with representative remedial action technologies for soil. Based on site use and type and extent of contaminants, these remedial action technologies were screened to identify a list of technologies to include in a more detailed evaluation of potential remedial action alternatives. The results of the screening are shown in Table 1, with the shaded technologies eliminated from further consideration. Comments on the table explain the rationale for eliminating technologies from further consideration.

Remedial action technologies for soil that remained following the initial screening include:

- No Action;
- Monitoring;
- Institutional Controls (Access Control; Soil Management Plan [SMP]);
- Soil Excavation and Off-Site Disposal; and
- Capping.

As appropriate, technologies are combined to form functional alternatives (such as combining excavation and off-site disposal). Monitoring is considered to be part of each active alternative except No Action. The No Action alternative is kept through the screening process to serve as a baseline for comparison. Based on the technologies remaining after the initial screening, the proposed alternatives for detailed analysis include the following:

- No Action;
- Institutional Controls with Future Redevelopment;
- Capping; and
- Excavation and Disposal.

These alternatives are included in the evaluation of alternatives in Section 9.

9.0 Detailed Analysis of Remedial Action Alternatives

This section describes and evaluates each of the remedial action alternatives identified in Section 8. Feasibility of the alternatives was evaluated using the criteria in Section 6.2.

Following the evaluation, a comparative analysis of each alternative relative to the other alternatives was completed (Section 10). The comparative analysis serves as the basis for selecting the recommended remedial action alternative (Section 11).

9.1 No Action

Description. According to OAR 340-122-085(2), a No Action alternative must be evaluated as a remedial action alternative. The No Action alternative assumes that no action is taken, no monitoring is performed, and no costs are incurred.

Protectiveness. The No Action alternative is not protective because it allows contaminants to be left in place at concentrations that exceed protective levels.

Effectiveness. The No Action alternative does not effectively manage or eliminate risk.

Long-Term Reliability. The No Action alternative is not reliable because it does not manage or eliminate risk.

Implementability. The No Action alternative is the easiest of the alternatives to implement.

Implementation Risk. Since there are no construction or remediation activities associated with the No Action alternative, there is no risk to workers or the public during implementation of this alternative.

Reasonableness of Cost. There is no cost associated with the No Action alternative.

9.2 Institutional Controls with Future Redevelopment

Description. Institutional controls for the Facility include limiting site access to authorized personnel only and implementation of a soil management plan (SMP). In accordance with recently implemented rules from Homeland Security, access to all Port facilities, including Terminal 4, is strictly controlled. The facilities are fenced and access is through a gated entrance manned full-time by security personnel. The SMP will delineate remedial action areas, identify appropriate soil-handling and protective measures for construction activities within the remedial action areas at the Facility, and identify inspection/maintenance requirements for the existing capped area.

If more intensive use of the remedial action areas is planned in the future, these areas will require redevelopment. Redevelopment will include one or more of soil excavation, filling, paving, or building construction. These elements will serve to reduce potential risk by either removing the soil with PAHs or serving as a cap to prevent contact by occupational workers. In this manner, the redevelopment is a part of the remedy. Redevelopment activities would be documented and appended to the SMP.

The Wheeler Bay area is capped. That cap would be maintained as part of this remedy.

Protectiveness. Institutional controls are protective under current conditions by limiting access to only authorized personnel and administratively eliminating direct contact with the impacted soil. For the future occupational worker, the redevelopment will remove the risk (through excavation) or prevent direct contact by capping the soil. The SMP will assure that the current cap at Wheeler Bay and future development remain protective.

Effectiveness. Because this is a controlled facility, institutional controls are effective means of managing risk. The existing cap (and future redevelopment) can easily be incorporated into the remedy to effectively manage future risk. Protection can be achieved in a short timeframe.

Long-Term Reliability. Institutional controls can remain effective for as long as the SMP is enforced (including continued worker education). Future redevelopment will serve as an effective cap.

Implementability. The institutional controls are easy to implement, but do require continued enforcement and education. The removal and/or capping associated with future redevelopment are considered easy to implement because these actions would be conducted as part of a planned development project.

Implementation Risk. Since there are no construction or remediation activities associated with the institutional controls, there is no short-term risk to workers or the public. During the future redevelopment project, potential risks are easily managed with engineering controls and personal protective equipment.

Reasonableness of Cost. The cost associated with the institutional controls/redevelopment alternative is low. The estimated cost is on the order of $10,000 to prepare an SMP with minor administrative costs on a long-term basis (Table 2). Regarding future costs associated with site redevelopment, only the present worth of the marginal cost associated with addressing contamination would be applicable to the FS. Assuming a capping scenario, the costs would be less because the costs would be part of the redevelopment.

9.3 Capping

Description. For this alternative, the shallow soil will be managed by containment (capping). The Wheeler Bay area is already capped and that cap would be maintained as part of this remedy. Soil in the cesspool area is beneath approximately 13 feet of clean overburden and risk associated with that soil would be managed through an SMP that is a part of this alternative. Figure 10 shows the area of the caps for the shallow soil in the northwest portion of OU1 and the soil stockpiles. The capping of these areas includes the following components.

- The shallow soil areas will be capped with asphalt-concrete pavement (with special measures involved with paving along the rail lines). Cap sections for the northwest caps will consist of 3 inches of asphalt concrete pavement over 6 inches of crushed, 3/4-inch (minus) gravel. Site grading prior to cap installation will be required to match top of cap grade to top of rail lines (maintaining the function of the rail lines at their current grade). Soil removed from the area as part of this grading will be transported to the soil stockpile area to be placed beneath the cap in that area. Areas apart from the rail lines will require re-grading, but no removal is needed (an area of about 1,000 square yards);
- The soil stockpiles would be capped with one foot of clean fill (obtained from an off-site borrow source). Prior to capping, the stockpiles would be graded to a uniform thickness of approximately 3 feet over an area of approximately 100,000 square feet. The surface would be planted with grass to prevent erosion.
- Long-term operation and maintenance of the caps will involve annual inspections, sealing observed cracks on an assumed schedule of every five years, and repair of erosion at the soil stockpile and Wheeler Bay caps.
- Management of risks during and following construction activities in these capped areas and the cesspool soils will be addressed with an SMP.

Capped areas could be redeveloped in the future if desired as long as the development is constructed and maintained to act as a cap for remaining soil containing PAHs above the RBCs. Redevelopment activities would be documented and appended to the SMP.

Protectiveness. The cap alternative is protective of human health by preventing direct contact with the soil and by preventing movement of the soil. There are no long-term sampling requirements. An SMP will be incorporated into the alternative to address risks associated with construction worker exposure in the remedial action areas and to address long-term requirements for inspection and maintenance of the caps.

Effectiveness. Because this is a controlled facility, capping is an effective means of managing risk. Capping can be implemented relatively quickly and is effective immediately after construction.

Long-Term Reliability. This alternative does not reduce the toxicity or mobility of the contaminants. However, toxicity reduction will occur through time by natural attenuation processes. The long-term reliability of this alternative requires maintenance of the caps and enforcement of the SMP.

Implementability. This remedial action alternative is moderately easy to implement, requiring physical measures (cap installation) and institutional measures (i.e., development of an SMP). The Wheeler Bay area is already capped. Implementation in a portion of the shallow soil area is somewhat complicated by the presence of the numerous rail lines that traverse the area.

Implementation Risk. Concentrations of PAHs are below construction worker RBCs, so there are only minor implementation risks to construction workers associated with installation of the caps in the shallow soil area and the soil stockpiles. These risks can be managed with engineering controls (e.g., dust control) and institutional controls (e.g., Health and Safety Plan). Some excess soil would be generated during grading for development of the cap and will be transported to the stockpile area for capping.

Reasonableness of Cost. The bulk of the implementation cost for this alternative would be the installation of the caps in the shallow soil and soil stockpile areas. Long-term costs include annual inspections and an assumed repair event (e.g., crack sealing, erosion repair) every five years. Other costs include the development of the SMP and the preparation of the implementation design. The total present-worth cost is estimated to be $430,000 (Table 2).

9.4 Excavation and Disposal

Description. For this alternative, the shallow soil, cesspool, and soil stockpile areas will be excavated for off-site disposal in a licensed landfill. The Wheeler Bay area is capped and would not be excavated. That cap would be maintained as part of this remedy. Figure 10 shows the area of the soil excavation. This alternative includes the following components:

- Temporarily remove existing rails/ties in the western remedial action area;
- Excavate and transport soil from the shallow soil remedial action, the cesspool, and the soil stockpile areas to a local special waste landfill (24,000 tons);
- Use clean imported fill to replace soil excavated from the shallow soil remedial action areas; use stockpiled clean overburden plus clean imported fill to replace excavated soil at the cesspool area; no replacement is required at the stockpile area;
- Replace rails/ties; and
- Prepare an SMP for the cap associated with Wheeler Bay.

Protectiveness. Landfill disposal achieves protection by removing the contaminated soil to a managed facility. The Wheeler Bay cap prevents direct contact with the soil. There are no long-term sampling requirements. Annual inspection and maintenance may be required at the Wheeler Bay cap. An SMP will be incorporated into the alternative to address requirements and risks associated with the Wheeler Bay cap.

Effectiveness. This alternative is effective because the soil in the potential development areas is removed off-site to a controlled landfill. The remaining capped area can be effectively managed because the Facility access is strictly controlled. The alternative is protective immediately after implementation (expected to take two months to complete).

Long-Term Reliability. Disposing of the soil at a landfill will eliminate the human health risk from the soil by removing the contaminant source to a managed facility. Landfill disposal does not reduce the toxicity or mobility of the contaminants. This alternative otherwise has good long-term reliability because the landfill is a controlled disposal facility that will be required to conduct long-term maintenance and monitoring. There are limited maintenance requirements associated with the Wheeler Bay cap and enforcement of the SMP.

Implementability. This remedial action alternative is moderately easy to implement, requiring physical measures (soil excavation) and institutional measures (development of an SMP). Wheeler Bay has an existing cap. Implementation in a portion of the shallow soil area is somewhat complicated by the presence of the numerous rail lines that traverse the area, and implementation in the cesspool area is complicated by a relatively deep excavation adjacent to a building.

Implementation Risk. Risks that may be realized during implementation of this alternative include exposure to construction workers during the soil excavation (which is minor because PAH concentrations are below construction worker RBCs and can be managed through engineering controls and worker protection) and the potential for spilling of soil during transport to the landfill area. Trucks would be covered to prevent material spilling.

Reasonableness of Cost. The estimated total cost of this remedial action alternative is on the order of $2,460,000. The approximate breakdown of this cost estimate is as follows (additional detail in Table 2):

Railway Removal	$ 110,000
Excavation and Disposal	$ 1,800,000
Backfill and Compaction	$ 190,000
Rail Reconstruction	$ 260,000
Engineering and Reporting	$ 100,000
Total	$ 2,460,000

10.0 Comparative Evaluation of Remedial Action Alternatives

This section of the FS presents an evaluation of the remedial action alternatives relative to one another. The comparative analysis is summarized in Table 3. In the table, each alternative is compared to each of the other alternatives for each evaluation criterion. An alternative is ranked as favorable (+), equal (0), or unfavorable (-) in relation to every other alternative. The scores are summed at the right of the table for each alternative and the alternatives are ranked. The following discussion provides the rationale for the comparative evaluation presented in Table 3.

10.1 Protectiveness

This criterion is pass/fail. An alternative must be protective as defined by OAR 340-122-040 to be acceptable. With the exception of the No Action alternative, each of the remedial action alternatives is protective of human health. The alternatives were not scored based on this criterion, but protectiveness was considered when ranking the alternatives in the right-hand column.

10.2 Effectiveness

The alternatives were ranked based on effectiveness of the alternative and the time required to complete the remedial action. The Excavation/Disposal alternative ranked higher than the Capping alternative because the contamination in the excavation areas is completely removed to a controlled facility. The Capping alternative and the Institutional Controls/Redevelopment alternative are both expected to be effective immediately upon implementation and thus ranked similarly. The No Action alternative was not considered an effective remedial alternative.

10.3 Long-Term Reliability

Alternatives that permanently treat (or dispose of) the contamination ranked the highest. The Excavation/Disposal alternative is considered more permanent and reliable than the Capping alternative in the long-term because the contaminated soil from the excavation areas is removed to a controlled facility. The Institutional Controls/Redevelopment alternative requires administrative upkeep to be reliable, and thus ranks lower than the alternatives that involve physical measures. The No Action alternative was not considered a reliable remedial alternative.

10.4 Implementability

The No Action alternative was considered the most easily implemented remedial action. The Institutional Controls/Redevelopment alternative ranked next because no site construction activities would be required (related directly to site remediation). The Excavation/Disposal alternative has significantly more complicated construction activities and thus ranks lower than the Capping alternative.

10.5 Implementation Risk

The No Action alternative carries no implementation risk. There is minor risk associated with implementation of the Institutional Controls/Redevelopment alternative because of the potential for construction worker exposure. The Capping alternative and the Excavation/Disposal alternative carry more risk because of the higher potential for contact with contaminated soil. The Excavation/Disposal alternative ranks lower than Capping because it includes transport of contaminated soil over public roadways.

10.6 Reasonableness of Cost

Cost estimates were developed for each of the remedial options based on capital and long-term costs. The following list summarizes the present-worth total cost estimates for each alternative.

- No Action ($0);
- Institutional Controls/Redevelopment ($10,000);
- Capping ($430,000); and
- Excavation and Disposal ($2,460,000).

11.0 Recommendation

11.1 Recommended Remedial Action Alternative

Based on the evaluation of remedial action alternatives, the highest ranking protective alternative is the Institutional Controls/Redevelopment alternative. This alternative is recommended as being protective (under the administration of an SMP in the short term and through redevelopment in the long term), easy to implement, and is the most cost-effective of the protective alternatives.

11.2 Residual Risk Assessment

As part of this evaluation, in accordance with OAR 340-122-084(4), a Residual Risk Assessment was completed for the recommended remedial action alternative. The Residual Risk Assessment included a quantitative assessment of risk resulting from unmanaged residuals at the Facility and a calculation of the managed risk. In this case, the residual risk is that potential risk for future occupational workers posed by soil PAHs outside of the remedial action areas, and the managed risk is the potential risk associated with occupational exposure exclusively to the managed area. If the residual risk is below acceptable levels, then an assessment of the adequacy and reliability of any additional institutional controls is not necessary.

Consistent with the HHRA (Ash Creek/Newfields, 2007a), the reasonable maximum exposure (RME) values for exposure parameters relating to occupational employees and excavation/construction workers were used in these calculations (refer to the Risk Assessment for details). For individual chemicals, DEQ generally considers excess cancer risks below 1.0×10^{-6} to be acceptable; for additive risks from multiple chemicals, DEQ considers risks less than 1.0×10^{-5} to be acceptable (OAR 340-122-115(2)(a), (3)(a)). The results of the Residual Risk Assessment are summarized in Tables 4 and 5.

Based on the Risk Assessment for the Facility, the overall risk to human health from additive exposure to multiple PAHs in OU1 was estimated to be approximately $6x10^{-6}$ for the occupational worker exposure pathway. Implementation of the selected remedial action alternative (Institutional Controls/Redevelopment) for the remedial action areas would reduce this risk to $8x10^{-7}$, and the 90-percent upper confidence limit (%UCL) of the mean for each of benzo(a)pyrene and dibenz(a,h)anthracene in OU1 would be below the RAO of 0.27 mg/kg. The risk managed by the Institutional Controls/Redevelopment alternative associated with the remedial action areas is $3x10^{-5}$. The residual Risk Assessment concludes that the implementation of the Institutional Controls/Redevelopment alternative (SMP together with future redevelopment) would effectively reduce risk to potential future site workers to acceptable levels.

12.0 References

AINW, 2003. A Cultural Resources Reconnaissance Survey of the Port of Portland's Terminal 4, Portland, Oregon. April 11, 2003.

Anchor, 2008. Final Design Analysis Report: Terminal 4 Phase I Removal Action. Prepared for the Port of Portland by Anchor Environmental, L.L.C. June 2008.

Anchor, 2010. Final Wheeler Bay Shoreline Stabilization Slope Repair Removal Action Work Plan, Terminal 4 Phase I Removal Action. Prepared for the Port of Portland. September 2010.

Ash Creek Associates/Newfields, 2007a. Upland Facility Remedial Investigation Report, Port of Portland - Terminal 4 Slip 1, Portland, Oregon. August 14, 2007.

Ash Creek Associates/Newfields, 2007b. Source Control Alternatives Evaluation, Terminal 4 Slip 1 Upland Facility, Operable Unit 2, Portland, Oregon. February 2007.

Ash Creek Associates, 2009a. Letter to K. Madalinski, Port of Portland, T4 Utility Rack Infrastructure Improvement – Surface Sampling Results, Terminal 4 Slip 1. June 30, 2009.

Ash Creek Associates, 2009b. FINAL - Storm Water Data Summary Report, Terminal 4 Slip 1 and Slip 3 Upland Facilities, Port of Portland, Portland, Oregon. March 2009.

Ash Creek Associates, 2009c. Storm Water Source Control Evaluation, Terminal 4 Slip 1 and Slip 3 Upland Facilities. September 2009.

Ash Creek Associates, 2009d. Wheeler Bay Source Control Completion Report, Terminal 4 Slip 1 Upland Facility. September 2009.

Ash Creek Associates, 2010. Letter to K. Madalinski, Port of Portland, Surface Soil Sampling, Terminal 4 Slip 1 – Operable Unit 1. April 9, 2010.

Ash Creek Associates, 2011. Letter to D. Breen, Port of Portland, Stockpile Sampling Results, Port of Portland Terminal 4 Slip 1. July 18, 2011.City of Portland, 2004a. Bureau of Planning zoning maps, northwest quarter. http://www.planning.ci.portland.or.us. March 22, 2004.

City of Portland, 2004b. Bureau of Planning Comprehensive Plan Map. http://www.planning.ci.portland.or.us/sections/citymaps/citycmp.pdf. March 22, 2004.

DEQ, 1998a. Guidance for Conducting Feasibility Studies. Oregon Department of Environmental Quality, Waste Management and Cleanup Division. July 1, 1998.

DEQ, 1998b. Consideration of Land Use in Environmental Remedial Actions. July 1, 1998.

DEQ, 1998c. Guidance for Conducting Beneficial Water Use Determinations at Environmental Cleanup Sites. July 1, 1998.

DEQ, 2003. Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites. Oregon Department of Environmental Quality, Land Quality Division, Environmental Cleanup and Tanks Program. September 22, 2003 (Updated September 15, 2009).

DEQ, 2008. Letter to K. Madalinski, Port of Portland, Draft Feasibility Study, Port of Portland Terminal 4, Slip 1 Upland Facility. October 14, 2008.

DEQ, 2010. Letter to K. Madalinski, Port of Portland, Storm Water Source Control Evaluation, Port of Portland Terminal 4, Slip 1 and 3 Upland Facilities, ECSI #2365 and 272. March 5, 2010.

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. United States Environmental Protection Agency, Office of Emergency and Remedial Response, EPA-540-G-89-004. October 1988.

Hart Crowser, 2004. Remedial Investigation Work Plan, Terminal 4 Slip 1 Upland Facility, Portland, Oregon. August 20, 2004.

NOAA, 2003. Willamette River Data and Maps, Query Manager 2.5, Marplot 3.3 (on CD). U.S. Department of Commerce. September 2003.

Port of Portland, 2010. Letter to T. Gainer, Oregon Department of Environmental Quality, Terminal 4 Slip 1 and Slip 3 Upland Facilities, Storm Water Source Control Evaluation, Response to DEQ Comments Provided December 14, 2009, ECSI Nos. 2356 and 272. January 29, 2010.

USGS, 1984. U.S. Geological Survey 7.5-Minute Quadrangle Map, Linnton, Oregon.

Table 1
Initial Screening and Evaluation of Technologies for Shallow Soil
Port of Portland Terminal 4 Slip 1
Portland, Oregon

General Response Action	Technology	Description	Evaluation Criteria: Protectiveness/ Short-Term Effectiveness	Permanence/ Long-Term Effectiveness	Costs	Implementability	Management of Short-Term Risks	Screening Comments
NO ACTION	None	No Action.	--	--	++	++	++	Is not effective, but is retained in accordance with FS rules and guidance as baseline for comparison.
INSTITUTIONAL/ ENGINEERING CONTROLS	Access Restriction	Restrict access with physical, legal, and/or procedural barriers to prevent or control contact with contaminated soil. Examples include controlling site access to authorized personnel or implementing a Soil Management Plan.	+	0	++	+	++	Potentially applicable and effective. Has lowest cost of applicable alternatives, is relatively easy to implement, and has little or no risks to the public or workers during implementation.
	Monitoring	Laboratory analysis of soil samples to document soil conditions.	NA	NA	+	+	+	Applicable only to documenting site conditions and the effectiveness of other treatment technologies.
REMOVAL	Excavation and Off-site Disposal	Contaminated soil would be excavated from the site and disposed of at an appropriate off-site facility (with or without pretreatment).	++	++	--	0	-	Shallow soil excavation complicated by presence of rail lines, excavation of deeper soil would require shoring to protect adjacent buildings; cost would be high and would have increased implementation risk.
CONTAINMENT	Capping	Installation of cover to prevent contact with contaminated soil.	+	0	0	0	+	Potentially applicable and effective. Moderate level of long-term effectiveness (requires maintenance), ease of implementation, and cost. Minor risks during implementation associated with potential worker contact and longer implementation duration than institutional controls.
IN SITU BIOLOGICAL TREATMENT	Bioventing	Delivering oxygen to contaminated (unsaturated) soils by forced air movement to stimulate biodegradation.	--	0	0	--	0	PAHs not readily amenable to *in situ* biodegradation treatment, with low degradation rates. Shallow soil is already uncovered and likely well oxygenated, therefore this treatment would not be effective beyond current conditions.
	Enhanced Bioremediation (Bioaugmentation, Biostimulation)	Adding nutrients, electron donors/acceptors, selected microbial cultures, or other amendments to enhance bioremediation.	-	+	-	--	0	PAHs not readily amenable to enhanced biodegradation, with low degradation rates. Less suitable for unsaturated soil.
	Land Treatment	Combination of aeration (tilling) and amendments to enhance bioremediation in surface soils.	0	+	-	--	-	PAHs not readily amenable to enhanced biodegradation, with low degradation rates. Not compatible with current and future land use. Not suitable for deep soil area.
	Natural Attenuation	Using natural processes to reduce contaminant concentrations to acceptable levels.	--	--	++	++	++	Natural processes likely will not reduce contaminant concentrations to acceptable levels within reasonable timeframe (> 10 years).
	Phytoremediation	Using plants to remove, transfer, stabilize, or destroy contaminants in soil.	--	-	-	--	0	Less effective with PAHs. Land use requirements not compatible with site use. Low PAH concentrations may not be amenable to significant plant uptake.
IN SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Chemical Oxidation	Chemically converts hazardous contaminants to less toxic compounds by oxidation.	0	+	--	--	--	Less effective for PAHs. Relatively high cost and implementation risk. Delivery to shallow unsaturated soil would be difficult.
	Electrokinetic Separation	Use of electrochemical/electrokinetic processes to desorb and remove metals and polar organics.	0	0	-	--	-	Would require introduction of surfactant or organic modifier. Less effective in shallow soil (would need to include flushing and capture).
	Fracturing	Development of cracks in low permeability or overconsolidated soils to create passageways that increase the effectiveness of other *in situ* processes and extraction technologies.	NA	NA	+	--	+	Applicable only to improve effectiveness of other technologies. Not necessary for site conditions (primarily coarse-grained soil). Not effective in shallow soil.
	Low-Flow Ventilation	Low-flow fan used to create low pressure directly beneath building slabs and prevent vapor migration into buildings.	--	--	0	--	--	Not effective for site conditions consisting of shallow uncovered soil contaminated by semi-volatile compounds
	Soil Flushing	Water (or water containing an additive to enhance contaminant solubility) is circulated through the soil to desorb contaminants, recovered, and treated.	-	-	-	-	-	Less effective for PAHs. Would require surfactant and circulation infrastructure.

Notes:
1. Shading represents technologies that have been eliminated from consideration.
2. Technology Rating: (++) Very Positive; (+) Positive; (0) Neutral; (-) Negative; (--) Very Negative

Table 1
Initial Screening and Evaluation of Technologies for Shallow Soil
Port of Portland Terminal 4 Slip 1
Portland, Oregon

General Response Action	Technology	Description	Evaluation Criteria: Protectiveness/ Short-Term Effectiveness	Permanence/ Long-Term Effectiveness	Costs	Implementability	Management of Short-Term Risks	Screening Comments
IN SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT (continued)	Soil Vapor Extraction	Vacuum is applied through vapor extraction wells to create a pressure/concentration gradient that induces vapor-phase volatiles to be removed from soil.	--	--	-	--	--	Not effective for PAHs.
	Solidification/ Stabilization/ Vitrification	Contaminants are physically bound or enclosed within a stabilized mass (solidification and vitrification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	0	0	--	-	0	Generally used for inorganic contaminants. Would impact site operations. High implementation cost.
	Thermally Enhanced Soil Vapor Extraction Treatment	High energy injection (steam/hot air, electrical resistance, electromagnetic, fiber optic, radio frequency) is used to increase the volatilization rate of semi-volatiles and facilitate extraction.	+	+	--	--	-	Less effective for shallow soil area. High implementation cost.
EX SITU BIOLOGICAL TREATMENT	Biopiles	Excavated soils are mixed with soil amendments and placed in aboveground enclosures and aerated with blowers or vacuum pumps.	-	+	0	-	-	Target compounds (PAHs) not readily conducive to this treatment. Land use requirements are not compatible with site use. Would be combined with excavation.
	Composting	Excavated soil is mixed with bulking agents and organic amendments to promote microbial activity.	-	+	0	-	-	Degradation of target compounds (PAHs) using microbial enhancement is slow. Land use requirements are not compatible with site use. Would be combined with excavation.
	Landfarming	Excavated soil is placed in lined beds and periodically tilled to aerate the soil.	-	+	0	--	-	Target compounds not conducive to aeration. Degradation of target compounds (PAHs) by promoting microbial degradation is slow. Land use requirements are not compatible with site use. Would be combined with excavation.
	Slurry Phase Biological Treatment	An aqueous slurry of soil, sediment, or sludge with water and other additives is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. When complete, the slurry is dewatered and the soil is disposed of.	+	++	--	--	-	Handling of slurry and waste water is unnecessarily complex and expensive. Land use requirements are not compatible with site use. Would be combined with excavation.
EX SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Chemical Extraction	Excavated soil is mixed with an extractant which dissolves the contaminants. The resultant solution is placed in a separator to remove the contaminant/extractant mixture for treatment.	+	+	--	-	-	Additional treatment would be required for recovered extractant. Would be combined with excavation.
	Incineration	High temperatures are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.	++	++	--	0	-	Requires off-site transport to distant facility. Is expensive relative to other acceptable treatment/disposal technologies. Would be combined with excavation.
	Soil Washing	Contaminants are separated from the excavated soil with wash-water augmented with additives to help remove organics.	0	+	--	-	-	Less effective with target compounds (PAHs). Additional treatment would be required for wash water. Would be combined with excavation.
	Solar Detoxification	Contaminants are destroyed by photochemical and thermal reactions using ultraviolet energy in sunlight.	-	0	--	--	-	Marginally effective with target compounds, but land use requirements are not compatible with site use. Would be combined with excavation.
	Thermal Desorption/ Pyrolysis/ Hot Gas Decontamination	Waste soils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated.	++	++	--	-	-	Requires off-site transport to distant facility. Is expensive relative to other acceptable treatment/disposal technologies. Would be combined with excavation.
	Separation	Separation techniques concentrate contaminated solids through physical, magnetic, and/or chemical means. These processes remove solid-phase contaminants from the soil matrix.	-	0	-	-	-	Target compounds cannot be directly separated. Could remove uncontaminated coarse gravels with screening. Would be combined with excavation.

Notes:
1. Shading represents technologies that have been eliminated from consideration.
2. Technology Rating: (++) Very Positive; (+) Positive; (0) Neutral; (-) Negative; (--) Very Negative

Table 2
Estimated Costs For Individual Remedial Action Alternatives
Port of Portland Terminal 4 Slip 1
Portland, Oregon

Technology	Units	Unit Costs	Extended Cost	
No Action				
Estimated Total Cost				$0
Institutional Controls				
Preparation of Soil Management Plan	1 l.s.	$10,000	$10,000	
Estimated Total Cost (Present Worth)				$10,000
Capping				
Initial Costs				
Design	1 l.s.	$10,000	$10,000	
Grading (Removal and Transport to Soil Stockpile)	1,900 tons	$10 /ton	$19,000	
Grading (No Removal)	1,000 s.y.	$12 /s.y.	$12,000	
Paving (Base Course and Asphalt Section)	4,300 s.y.	$45 /s.y.	$193,500	
Engineering/Oversight	25 days	$1,500 /day	$37,500	
Grading (Soil Stockpile)	10,700 cy	$2 /cy	$21,400	
Soil Cover	3,600 cy	$10 /cy	$36,000	
Hydroseed/Irrigation	2.3 ac	$10,000 /ac	$23,000	
Soil Management Plan	1 l.s.	$10,000	$10,000	
Long Term Costs (Present Value*)				
Annual Inspections	30 years	$1,000 /year	$15,400	
Cap Maintenance (5-year schedule)	6 events	$20,000 /event	$53,800	
Estimated Total Cost (Present Worth)				$432,000
Excavation and Disposal				
Initial Costs				
Design	1 l.s.	$15,000	$15,000	
Rail Line Abandonment	2,800 l.f.	$38 /l.f.	$106,400	
Excavation and Disposal	24,000 tons	$75 /ton	$1,800,000	
Excavate, Backfill and Compact Clean Overburden	1,300 cy	$10 /cy	$13,000	
Backfill and Compaction (Import)	6,300 tons	$28 /ton	$176,400	
Rail Line Reconstruction	2,800 l.f.	$94 /l.f.	$263,200	
Engineering/Oversight	45 days	$1,500 /day	$67,500	
Reporting	1 l.s.	$10,000	$10,000	
Soil Management Plan	1 l.s.	$10,000	$10,000	
Estimated Total Cost (Present Worth)				$2,462,000

Notes:
1. Present value costs calculated with an annual discount rate of 5%.
2. Unit costs for rail line abandonment and reconstruction as provided by online 2008 National Estimator.

Table 3
Comparison of Remedial Action Alternatives
Port of Portland Terminal 4 Slip 1
Portland, Oregon

Release Area Alternative	Protective	Balancing Factors																				Score	Rank
		Effectiveness				Long-Term Reliability				Implementability				Implementation Risk				Reasonableness of Cost					
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D		
A) No Action	No		-	-	-		-	-	-		+	+	+		+	+	+		+	+	+	3	na
B) Institutional Control (Soil Management Plan)	Yes	+		0	-	+		-	-	-		+	+	-		+	+	-		+	+	2	1
C) Capping	Yes	+	0		-	+	+		-	-	-		+	-	-		+	-	-		+	-2	2
D) Excavation and Disposal	Yes	+	+	+		+	+	+		-	-	-		-	-	-		-	-	-		-3	3

Notes:

+ = The alternative is favored over the compared alternative (score=1)

0 = The alternative is equal with the compared alternative (score=0)

- = The alternative is less favorable than the compared alternative (score=-1)

na = Not protective, therefore not ranked

	vs Technology			
Technology A		B	C	D
Technology B	A		C	D
Technology C	A	B		D
Technology D	A	B	C	

Table 4
Occupational Worker Residual Risk Evaluation Using 90%UCL
OU1: Soils from Less Than or Equal To 3 feet, Excluding Sample Locations Within Managed Area
Port of Portland Terminal 4 Slip 1
Portland, Oregon

Constituents of Potential Concern (COPCs)		Mean Conc. (mg/kg)	90%UCL		Occupational Worker	
CASNo	Analyte		Value (mg/kg)	Data Distribution	Risk Based Concentration Corresponding to 10^{-6} Risk	Risk
Semivolatile Organics (PAHs)						
56-55-3	Benzo[a]anthracene	0.054	0.092	gamma*	2.7	3.E-08
50-32-8	Benzo[a]pyrene	0.079	0.14	gamma*	0.27	5.E-07
205-99-2	Benzo[b]fluoranthene	0.084	0.15	gamma*	2.7	6.E-08
53-70-3	Dibenz[a,h]anthracene	0.022	0.021	gamma*	0.27	8.E-08
193-39-5	Indeno[1,2,3-cd]pyrene	0.089	0.18	gamma*	2.7	7.E-08
					Cumulative Risk	8.E-07

Notes:

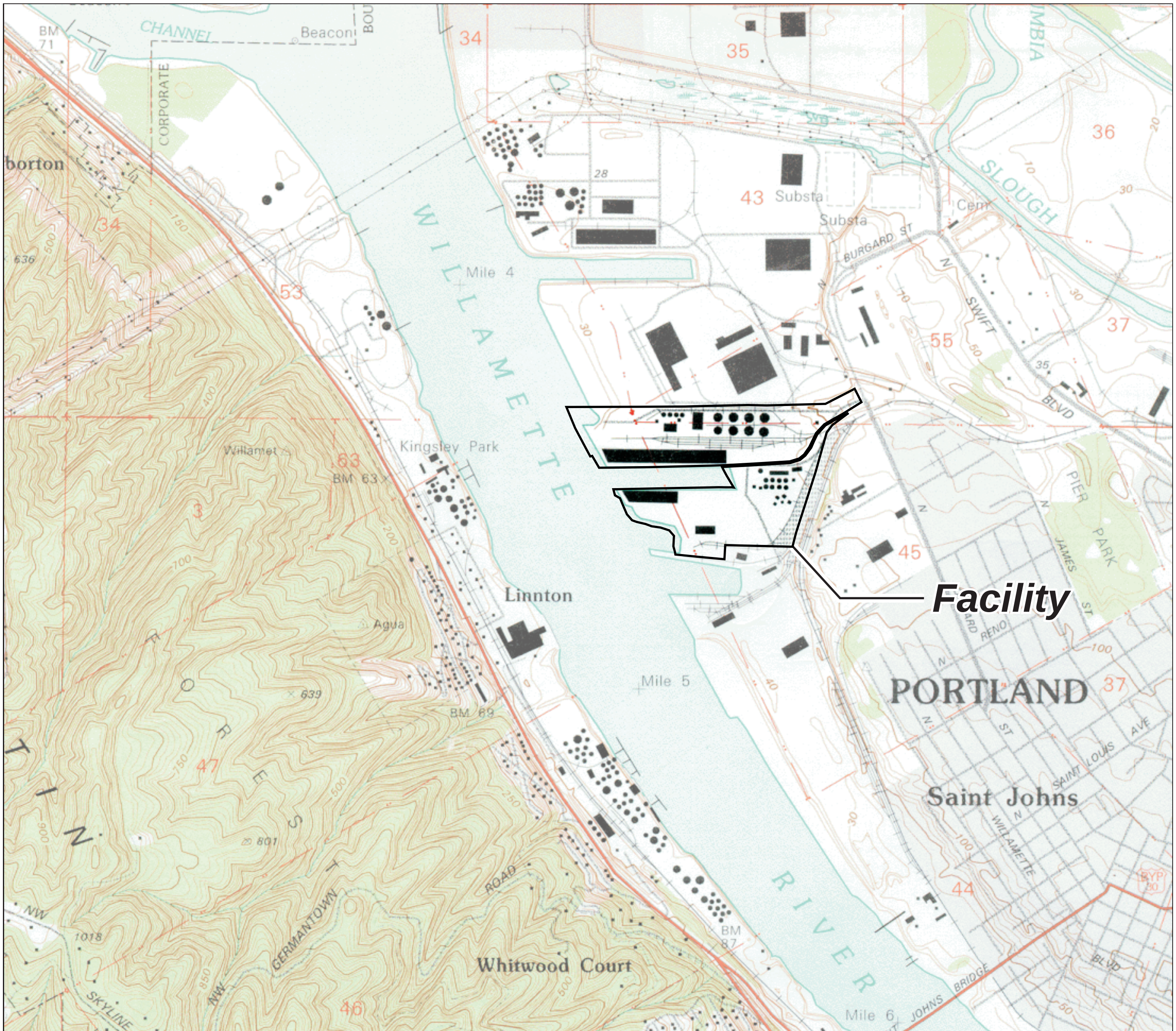
1. Sample locations outside managed area = S-5, S-6, S-11, SB-9, SB-14, SB-15, SB-16, SB-17, SB-18, SB-31, SB-33, SB-42, SB-45, SB-46, SB47, SB48, SB-49, SB-50, SB-82, SB-83 SB-89, SB-90, SB-92, SB-93, SB-94, SB-95, PL-1-1, PL-2-1, PL-3-1, PL-4-1, PL-5-1, PL-6-1, SS-1-1, SS-2-1, SS-3-1, SS-4-1, SS-5-1, SS-6-1, SS-7-1
2. 90%UCL = 90% Upper Confidence Limit on the Mean
3. Values in the table are excess individual lifetime risk of developing cancer. A cancer risk of 1 x 10^{-6} indicates that an additional 1 in 1,000,000 individuals would be expected to get cancer above the normal expected cancer rate.
4. Each data set was tested for distribution (normal, gamma, and lognormal); 90%UCL was calculated per EPA 2002. Non-parametric methods for calculating the 90%UCL were used when the distribution was unknown or when the distribution was highly skewed (>2.5) (*).
5. Equations were based on equations and parameters in DEQ (2000) and EPA (1996), and are summarized in Ash Creek/Newfields, Appendix A (2007a).
6. Oregon Department of Environmental Quality (DEQ), 2000. Guidance for Conduct of Deterministic Human Health Risk Assessments, Final December 1998, Updated May 2000.
7. U.S. Environmental Protection Agency (EPA), 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites, OSWER 9285.6-10. December 2002.
8. U.S. Environmental Protection Agency (EPA), 1996. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response, Washington, D.C. 9355.4-23. Second edition, July 1996.

Table 5
Occupational Worker Managed Risk Evaluation Using 90%UCL
OU1: Soils from Less Than or Equal To 3 feet - Sample Locations Associated Only With Managed Area
Port of Portland Terminal 4 Slip 1
Portland, Oregon

Constituents of Potential Concern (COPCs)		Mean Conc. (mg/kg)	90%UCL		Occupational Worker	
CASNo	Analyte		Value (mg/kg)	Data Distribution	Risk Based Concentration Corresponding to 10^{-6} Risk	Risk
Semivolatile Organics (PAHs)						
56-55-3	Benzo[a]anthracene	2.1	3.8	gamma	2.7	1.E-06
50-32-8	Benzo[a]pyrene	2.9	5.3	gamma	0.27	2.E-05
205-99-2	Benzo[b]fluoranthene	1.5	5.8	gamma	2.7	2.E-06
53-70-3	Dibenz[a,h]anthracene	0.67	1.3	gamma	0.27	5.E-06
193-39-5	Indeno[1,2,3-cd]pyrene	2.2	4.0	gamma	2.7	1.E-06
					Cumulative Risk	3.E-05

Notes:

1. Sample locations within managed area = S-7, S-12, S-13, S-15, S-16, S-17, S-18, S-19, SS-8-1, SS-8-2
2. 90%UCL = 90% Upper Confidence Limit on the Mean
3. Values in the table are excess individual lifetime risk of developing cancer. A cancer risk of 1 x 10^{-6} indicates that an additional 1 in 1,000,000 individuals would be expected to get cancer above the normal expected cancer rate.
4. Each data set was tested for distribution (normal, gamma, and lognormal); 90%UCL was calculated per EPA 2002. Non-parametric methods for calculating the 90%UCL were used when the distribution was unknown or when the distribution was highly skewed (>2.5) (*).
5. Equations were based on equations and parameters in DEQ (2000) and EPA (1996), and are summarized in Ash Creek/Newfields, Appendix A (2007a).
6. Oregon Department of Environmental Quality (DEQ), 2000. Guidance for Conduct of Deterministic Human Health Risk Assessments, Final December 1998, Updated May 2000.
7. U.S. Environmental Protection Agency (EPA), 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites, OSWER 9285.6-10. December 2002.
8. U.S. Environmental Protection Agency (EPA), 1996. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response, Washington, D.C. 9355.4-23. Second edition, July 1996.



Note: Base map prepared from the USGS 7.5-minute quadrangle of Linnton, Oregon, dated 1990.

N

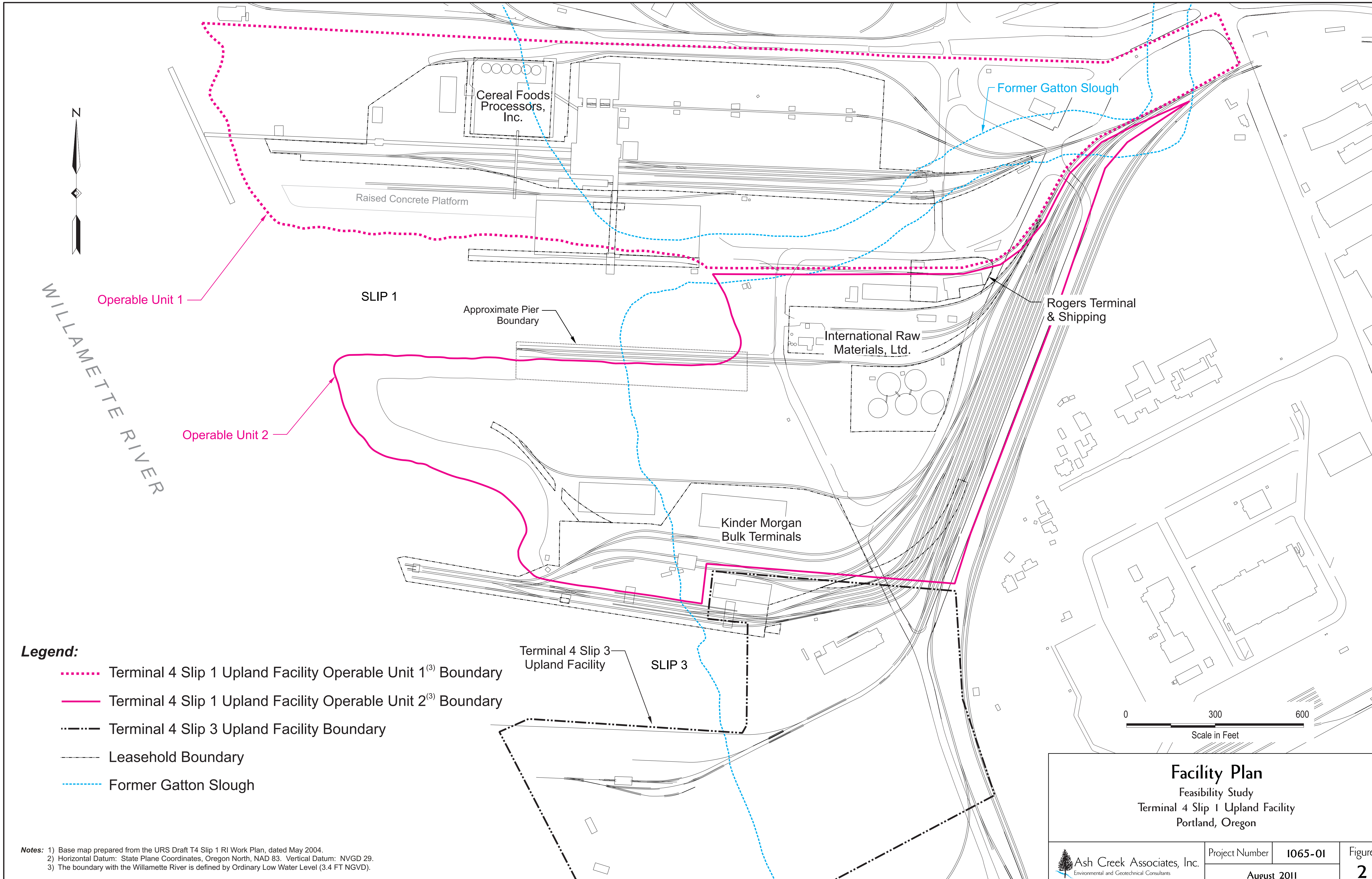
0 2,000 4,000

Approximate Scale in Feet

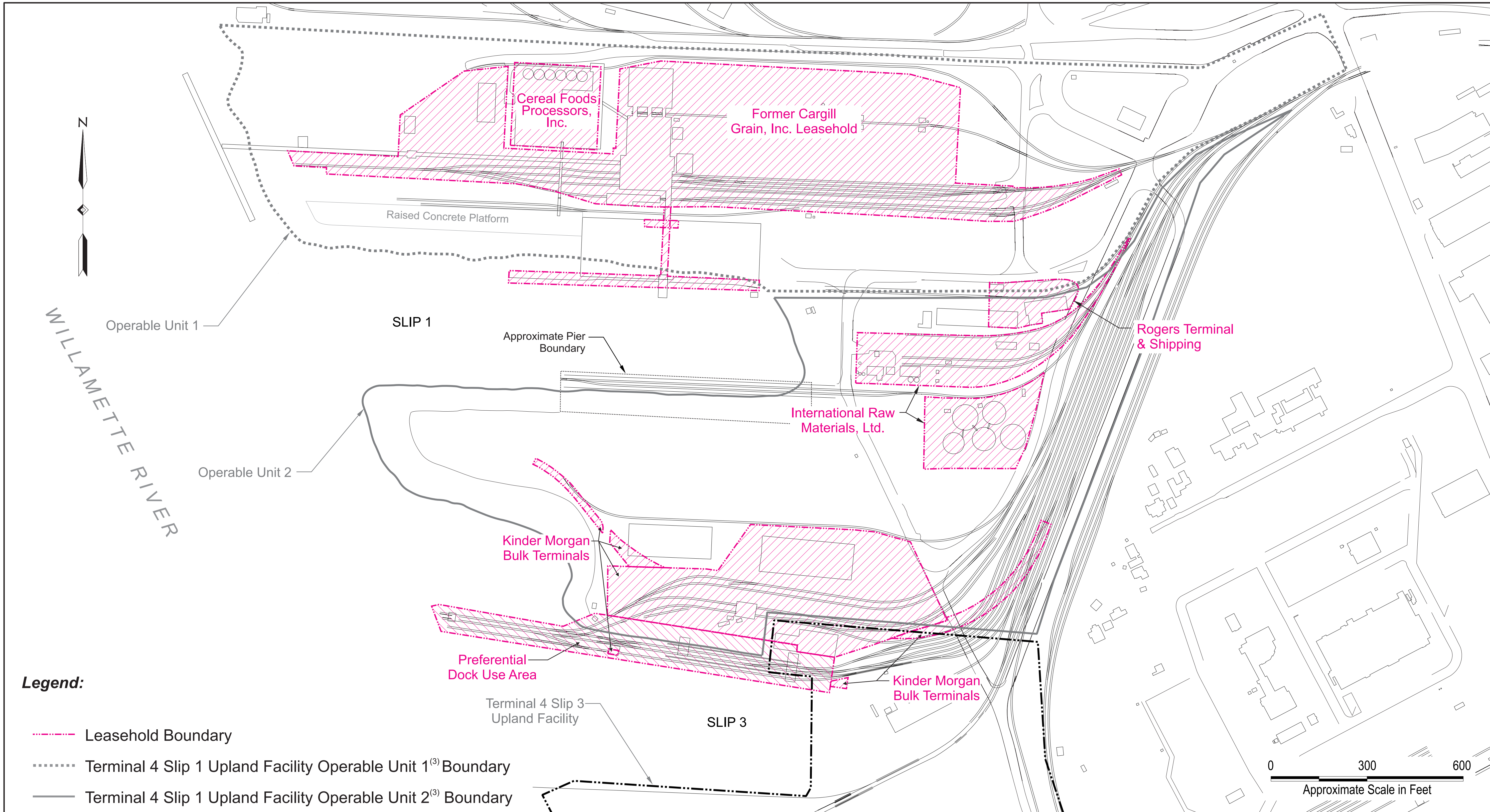
Site Location Map

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc. Environmental and Geotechnical Consultants	Project Number 1065-01	Figure
	August 2011	1



Former Gatton Slough
Cereal Foods Processors, Inc.
N
Raised Concrete Platform
WILLAMETTE RIVER
Operable Unit 1
SLIP 1
Approximate Pier Boundary
Rogers Terminal & Shipping
International Raw Materials, Ltd.
Operable Unit 2
Kinder Morgan Bulk Terminals
Terminal 4 Slip 3 Upland Facility
SLIP 3
Legend:
Terminal 4 Slip 1 Upland Facility Operable Unit 1(3) Boundary
Terminal 4 Slip 1 Upland Facility Operable Unit 2(3) Boundary
Terminal 4 Slip 3 Upland Facility Boundary
Leasehold Boundary
Former Gatton Slough
Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).
0
300
600
Scale in Feet
Facility Plan
Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon
Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants
Project Number
1065-01
August 2011
Figure
2



Legend:

- Leasehold Boundary
- Terminal 4 Slip 1 Upland Facility Operable Unit 1(3) Boundary
- Terminal 4 Slip 1 Upland Facility Operable Unit 2(3) Boundary
- Terminal 4 Slip 3 Upland Facility Boundary

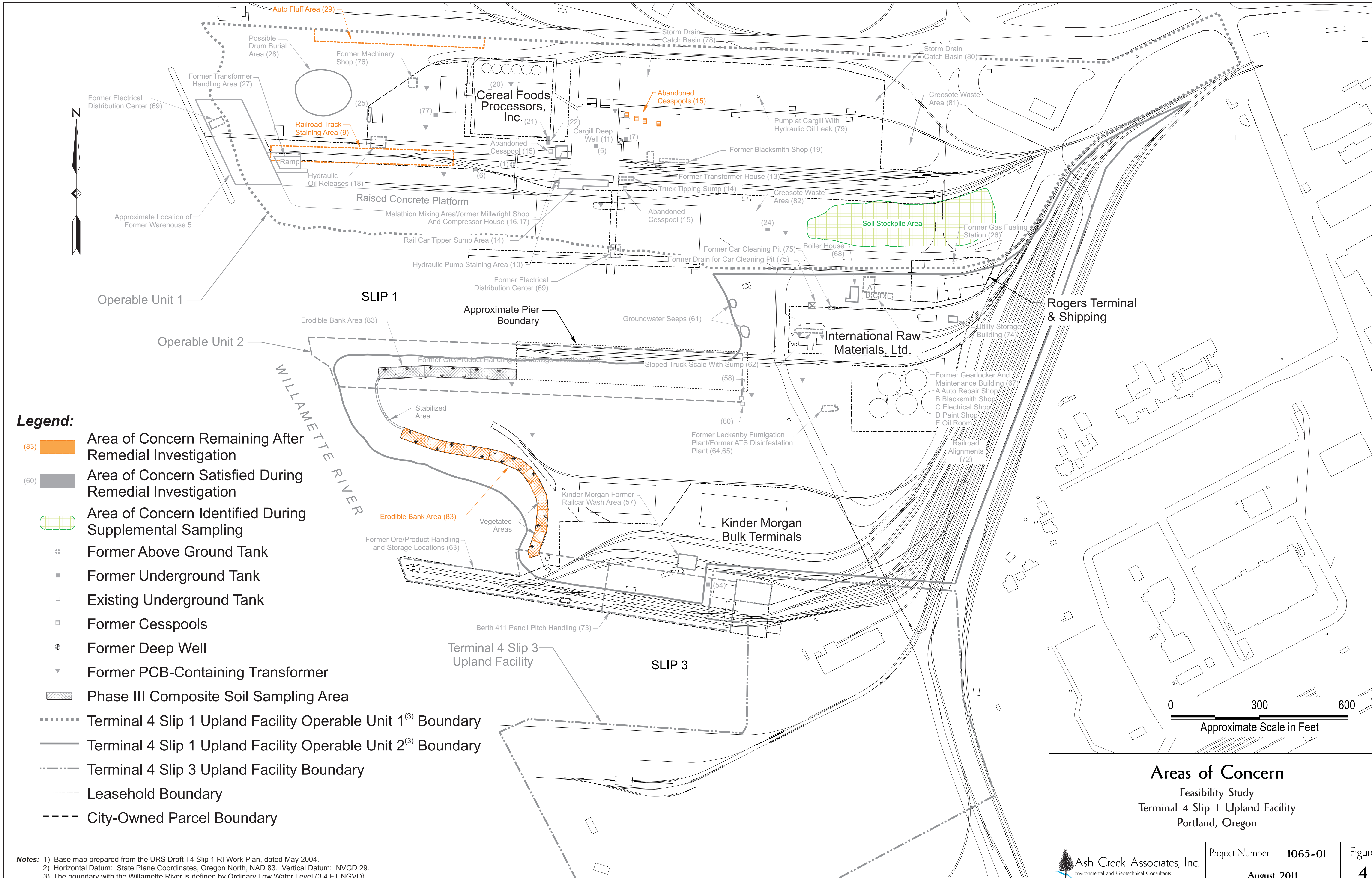
Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).

Leasehold Boundary Plan

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1065-01	Figure
	April 2010	3



Legend:

- (83) Area of Concern Remaining After Remedial Investigation
- (60) Area of Concern Satisfied During Remedial Investigation
- Area of Concern Identified During Supplemental Sampling
- Former Above Ground Tank
- Former Underground Tank
- Existing Underground Tank
- Former Cesspools
- Former Deep Well
- Former PCB-Containing Transformer
- Phase III Composite Soil Sampling Area
- Terminal 4 Slip 1 Upland Facility Operable Unit 1[3] Boundary
- Terminal 4 Slip 1 Upland Facility Operable Unit 2[3] Boundary
- Terminal 4 Slip 3 Upland Facility Boundary
- Leasehold Boundary
- City-Owned Parcel Boundary

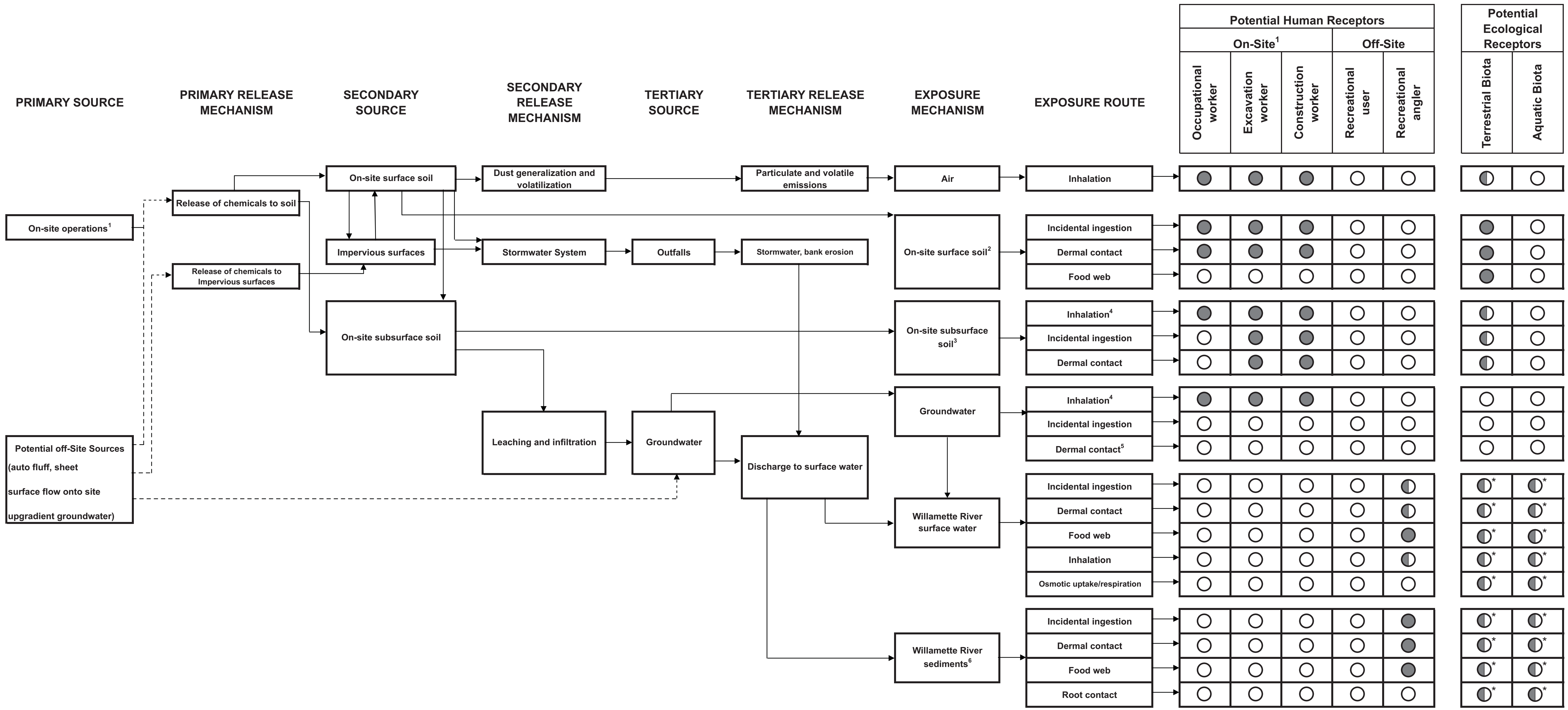
Notes:
1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).

Areas of Concern

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1065-01	Figure
August 2011		4



Notes:

1. "On-site" is defined as the upland portion of Port of Portland Terminal 4 Slip 1 (POP T4S1) facility.
2. Surface soil is defined as 0 to 3 feet below ground surface (bgs). Surface soil also includes riverbank areas with potentially erodable surfaces.
3. Subsurface is defined as 3 to 15 feet bgs.
4. In regard to potential inhalation of chemicals volatizing to surface air from site media at depth, occupational workers might be exposed to both indoor and outdoor air, while excavation and construction workers would be exposed to outdoor air only.
5. Once depth to groundwater is determined, pathway designations may change.
6. Exposure to Willamette River sediment will be addressed through the T4 removal action project and the Portland Harbor Superfund project.

Legend:

● = Potentially complete pathway

◐ = Potentially complete pathway; minor or insignificant

○ = Incomplete pathway

◐* = Potentially complete pathway; formal evaluation performed in Portland Harbor RI/FS. Pathway screened for groundwater to surface water transport under Joint Source Control Strategy guidance

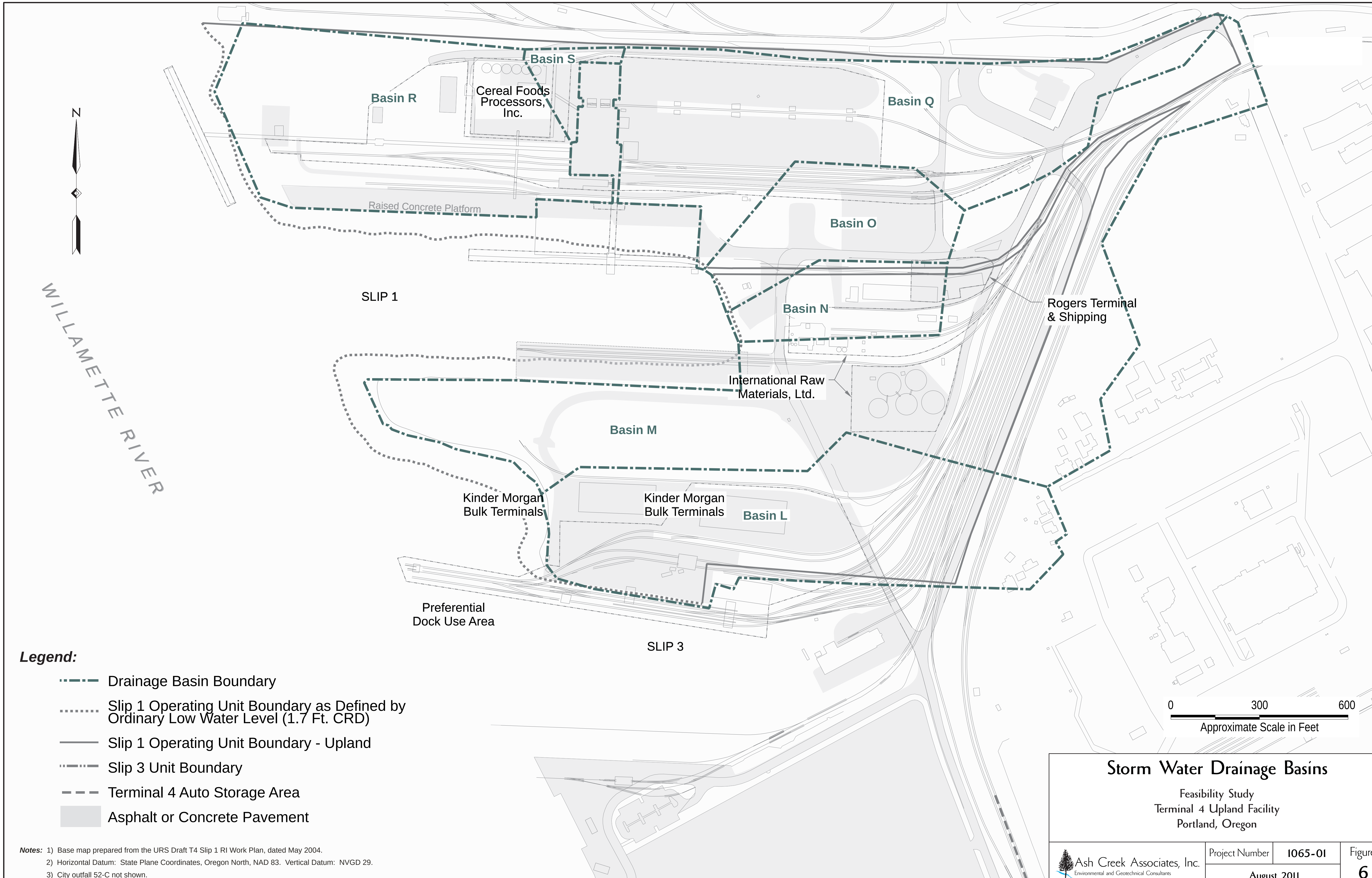
----- =Possible impacts from off-site sources.

Preliminary Conceptual Site Model of Human and Ecological Exposure Pathways

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1065-01	Figure
August 2011		5



Legend:

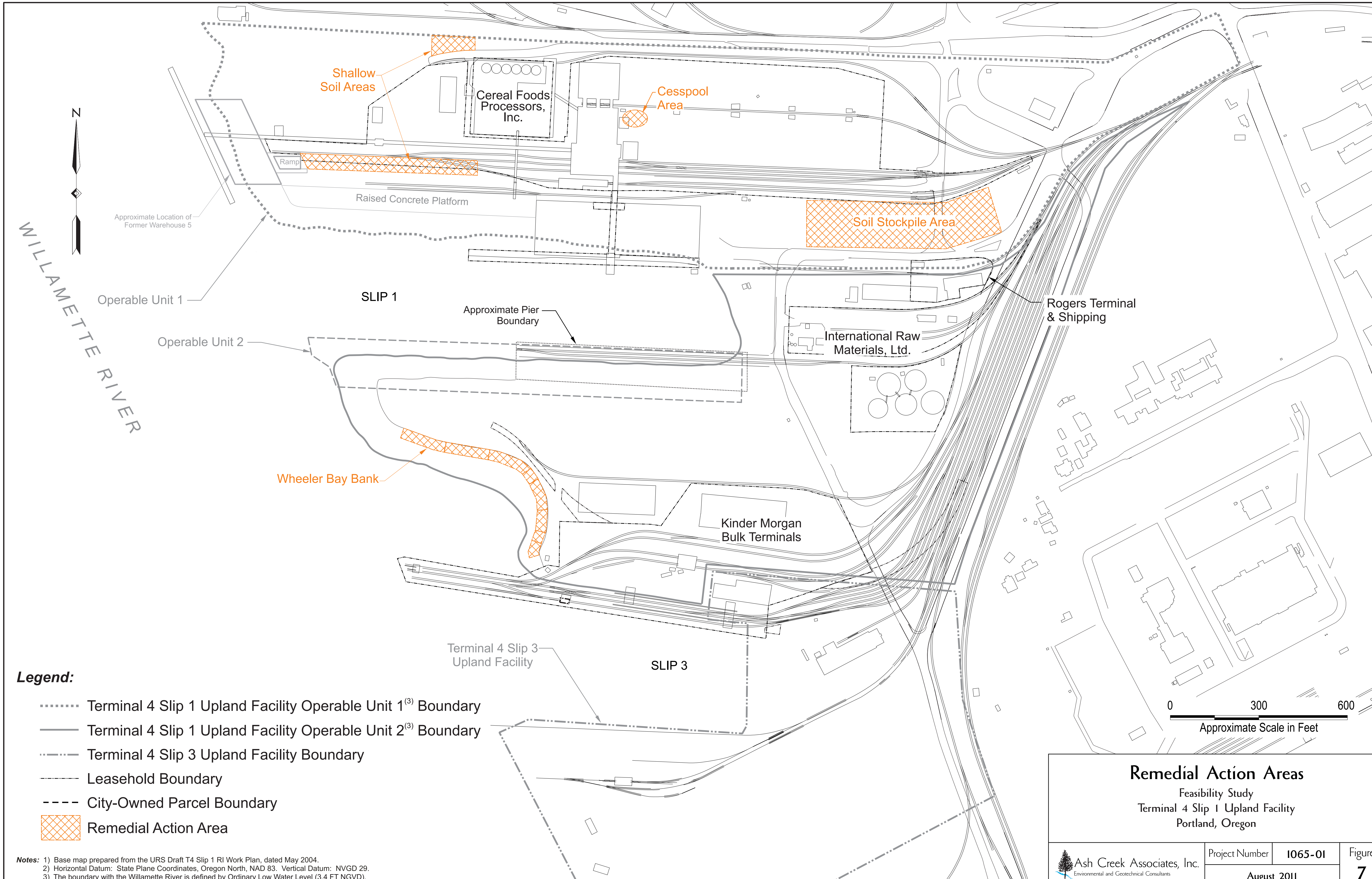
- Drainage Basin Boundary
- Slip 1 Operating Unit Boundary as Defined by Ordinary Low Water Level (1.7 Ft. CRD)
- Slip 1 Operating Unit Boundary - Upland
- Slip 3 Unit Boundary
- Terminal 4 Auto Storage Area
- Asphalt or Concrete Pavement

Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) City outfall 52-C not shown.

Storm Water Drainage Basins

Feasibility Study
Terminal 4 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc. Environmental and Geotechnical Consultants	Project Number	1065-01	Figure
	August 2011		6



Legend:

- Terminal 4 Slip 1 Upland Facility Operable Unit 1(3) Boundary
- Terminal 4 Slip 1 Upland Facility Operable Unit 2(3) Boundary
- Terminal 4 Slip 3 Upland Facility Boundary
- Leasehold Boundary
- City-Owned Parcel Boundary
- Remedial Action Area

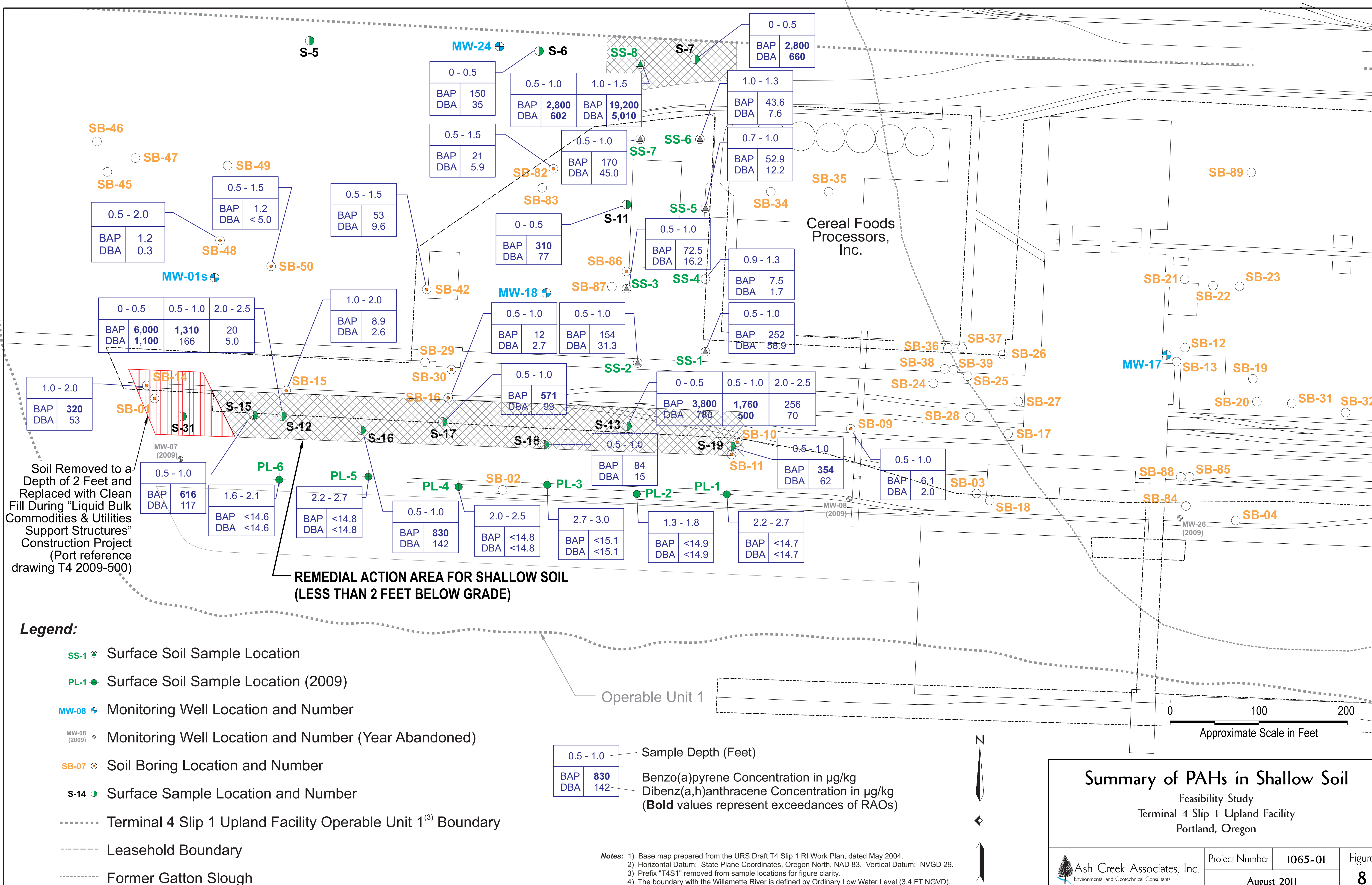
Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).

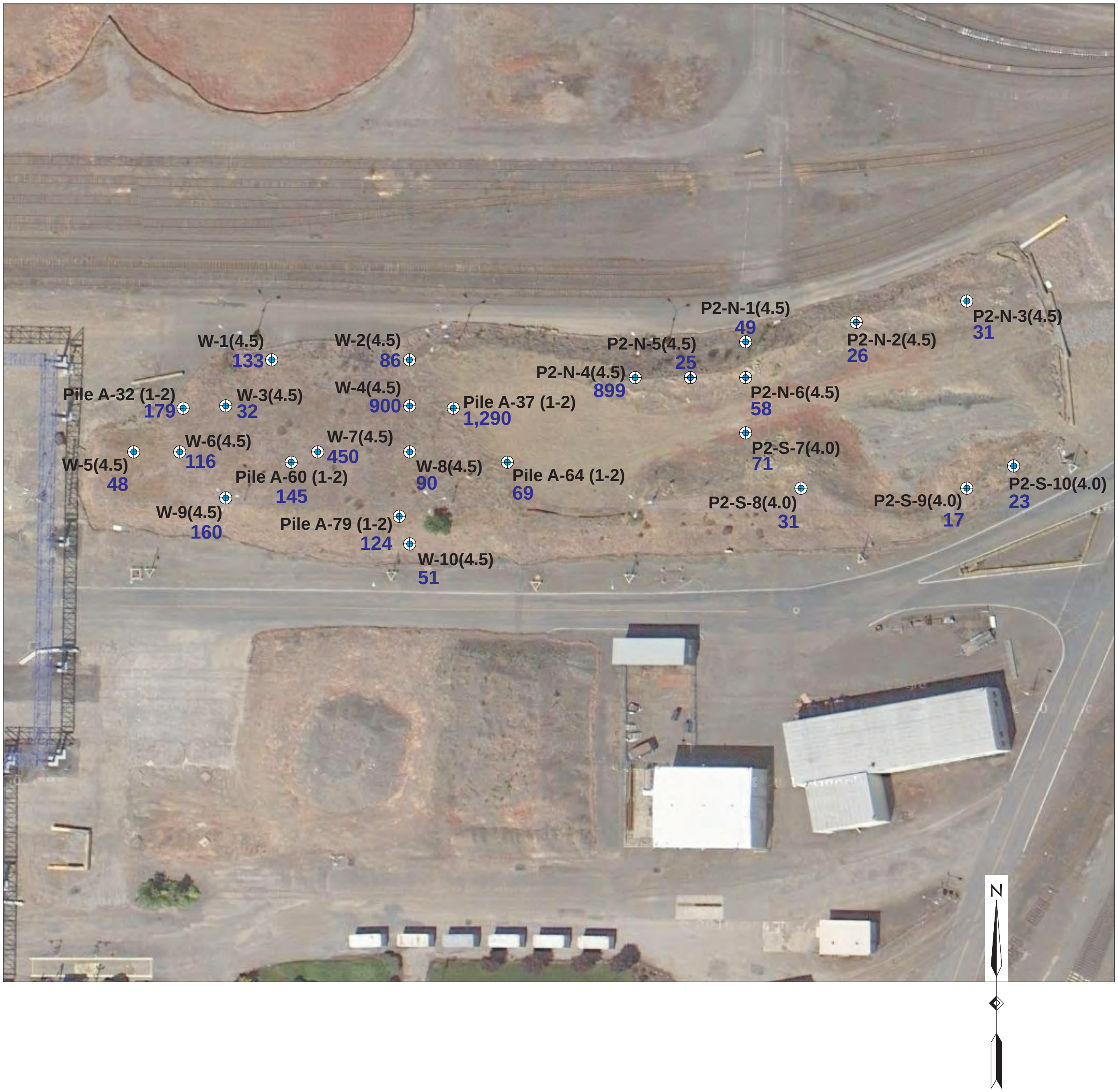
Remedial Action Areas

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1065-01	Figure
August 2011		7


S-5
MW-24
S-6
SS-8
S-7
0 - 0.5
BAP 2,800
DBA 660
0 - 0.5
BAP 150
DBA 35
0.5 - 1.0
BAP 2,800
DBA 602
1.0 - 1.5
BAP 19,200
DBA 5,010
1.0 - 1.3
BAP 43.6
DBA 7.6
MW
SB-46
SB-47
SB-49
SB-45
0.5 - 1.5
BAP 21
DBA 5.9
0.5 - 1.0
BAP 170
DBA 45.0
SS-7
SS-6
0.7 - 1.0
BAP 52.9
DBA 12.2
SB-82
SB-83
SB-35
SB-34
SB-89
0.5 - 1.5
BAP 1.2
DBA < 5.0
0.5 - 1.5
BAP 53
DBA 9.6
0.5 - 2.0
BAP 1.2
DBA 0.3
0 - 0.5
BAP 310
DBA 77
S-11
SS-5
0.5 - 1.0
BAP 72.5
DBA 16.2
Cereal Foods Processors, Inc.
SB-48
SB-50
SB-86
0.9 - 1.3
BAP 7.5
DBA 1.7
SS-4
SS-3
SB-87
MW-01s
SB-42
MW-18
SB-21
SB-23
SB-22
0 - 0.5
BAP 6,000
DBA 1,100
0.5 - 1.0
1,310
166
2.0 - 2.5
20
5.0
1.0 - 2.0
BAP 8.9
DBA 2.6
0.5 - 1.0
BAP 12
DBA 2.7
0.5 - 1.0
BAP 154
DBA 31.3
0.5 - 1.0
BAP 252
DBA 58.9
SB-29
SS-2
SS-1
SB-36
SB-37
SB-26
SB-12
SB-38
SB-39
MW-17
SB-13
SB-19
1.0 - 2.0
BAP 320
DBA 53
SB-14
SB-15
SB-30
0.5 - 1.0
BAP 571
DBA 99
0 - 0.5
BAP 3,800
DBA 780
0.5 - 1.0
1,760
500
2.0 - 2.5
256
70
SB-24
SB-25
SB-27
SB-20
SB-31
SB-32
SB-16
SB-01
S-15
S-31
S-12
S-16
S-17
S-18
S-13
SB-28
SB-09
SB-17
SB-10
0.5 - 1.0
BAP 84
DBA 15
S-19
0.5 - 1.0
BAP 354
DBA 62
0.5 - 1.0
BAP 6.1
DBA 2.0
SB-11
MW-07 (2009)
Soil Removed to a Depth of 2 Feet and Replaced with Clean Fill During “Liquid Bulk Commodities & Utilities Support Structures” Construction Project (Port reference drawing T4 2009-500)
0.5 - 1.0
BAP 616
DBA 117
PL-6
1.6 - 2.1
BAP <14.6
DBA <14.6
PL-5
2.2 - 2.7
BAP <14.8
DBA <14.8
PL-4
0.5 - 1.0
BAP 830
DBA 142
SB-02
2.0 - 2.5
BAP <14.8
DBA <14.8
PL-3
2.7 - 3.0
BAP <15.1
DBA <15.1
PL-2
1.3 - 1.8
BAP <14.9
DBA <14.9
PL-1
2.2 - 2.7
BAP <14.7
DBA <14.7
MW-08 (2009)
SB-03
SB-18
SB-88
SB-85
SB-84
MW-26 (2009)
SB-04
REMEDIAL ACTION AREA FOR SHALLOW SOIL (LESS THAN 2 FEET BELOW GRADE)
Legend:
SS-1 Surface Soil Sample Location
PL-1 Surface Soil Sample Location (2009)
MW-08 Monitoring Well Location and Number
MW-08 (2009) Monitoring Well Location and Number (Year Abandoned)
SB-07 Soil Boring Location and Number
S-14 Surface Sample Location and Number
Terminal 4 Slip 1 Upland Facility Operable Unit 1(3) Boundary
Leasehold Boundary
Former Gatton Slough
Operable Unit 1
0.5 - 1.0 Sample Depth (Feet)
BAP 830 Benzo(a)pyrene Concentration in µg/kg
DBA 142 Dibenz(a,h)anthracene Concentration in µg/kg
(Bold values represent exceedances of RAOs)
N
0 100 200
Approximate Scale in Feet
Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) Prefix "T4S1" removed from sample locations for figure clarity.
4) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).
Summary of PAHs in Shallow Soil
Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon
Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants
Project Number 1065-01
August 2011
Figure 8



Legend:

W-1(4.5) ⊕	Sampling Location
(4.5)	Sample Depth (Feet)
133	Benzo(a)pyrene Concentration in µg/kg

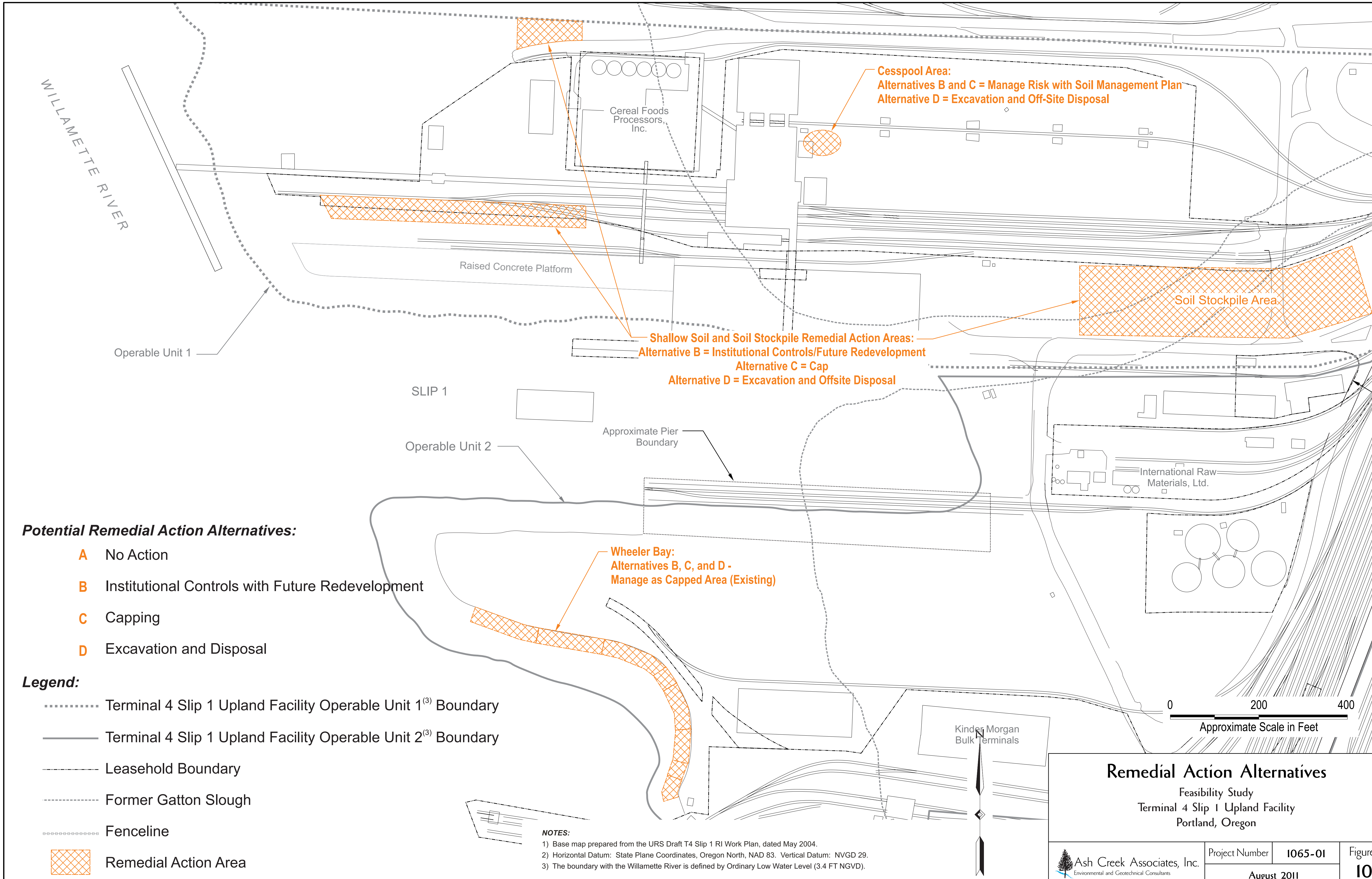
NOTES:
1) Base map prepared from 2011-Google Imagery. Aerial dated 8/15/2010.
2) Pile A samples collected in 2006
3) W and P2 samples collected in 2011

Summary of PAHs in Soil Stockpile Area

Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1065-01	Figure
August 2011		9


WILLAMETTE RIVER
Cereal Foods Processors, Inc.
Cesspool Area:
Alternatives B and C = Manage Risk with Soil Management Plan
Alternative D = Excavation and Off-Site Disposal
Raised Concrete Platform
Soil Stockpile Area
Operable Unit 1
Shallow Soil and Soil Stockpile Remedial Action Areas:
Alternative B = Institutional Controls/Future Redevelopment
Alternative C = Cap
Alternative D = Excavation and Offsite Disposal
SLIP 1
Approximate Pier Boundary
Operable Unit 2
International Raw Materials, Ltd.
Wheeler Bay:
Alternatives B, C, and D -
Manage as Capped Area (Existing)
Kinder Morgan Bulk Terminals
0
200
400
Approximate Scale in Feet
N
Potential Remedial Action Alternatives:
A No Action
B Institutional Controls with Future Redevelopment
C Capping
D Excavation and Disposal
Legend:
Terminal 4 Slip 1 Upland Facility Operable Unit 1(3) Boundary
Terminal 4 Slip 1 Upland Facility Operable Unit 2(3) Boundary
Leasehold Boundary
Former Gatton Slough
Fenceline
Remedial Action Area
NOTES:
1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).
Remedial Action Alternatives
Feasibility Study
Terminal 4 Slip 1 Upland Facility
Portland, Oregon
Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants
Project Number 1065-01
August 2011
Figure
10